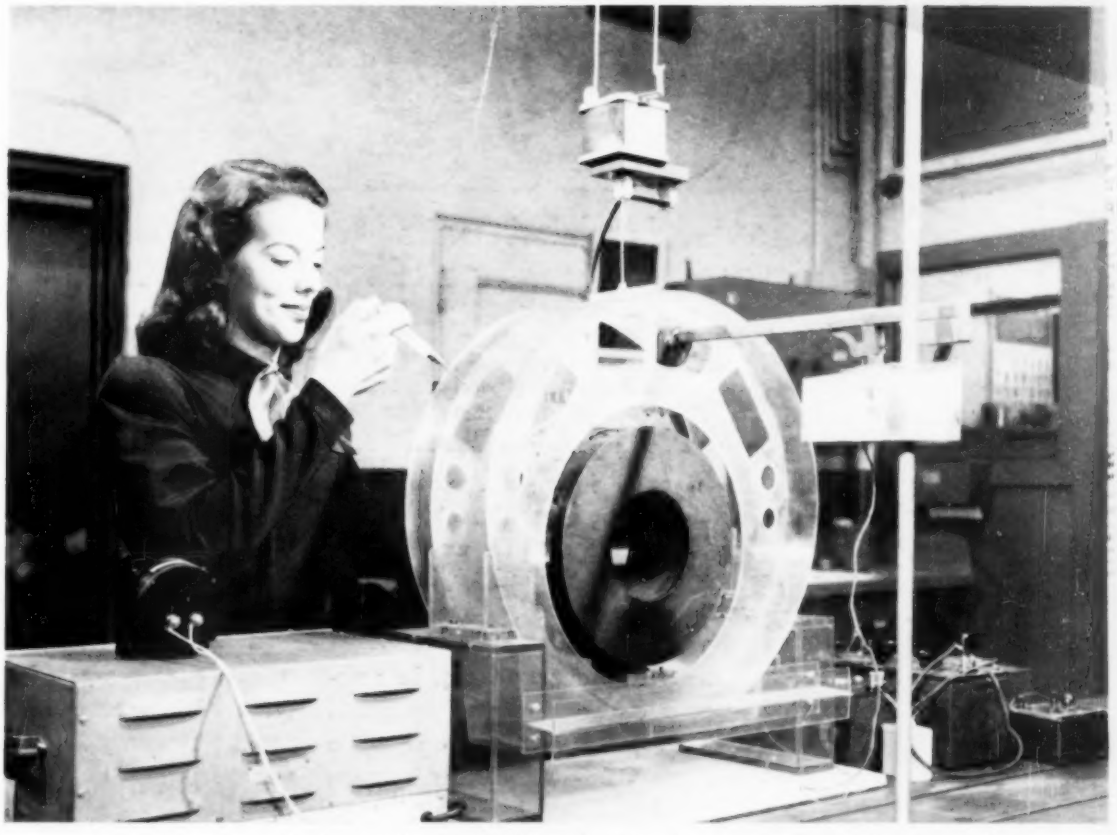
UNIV. OF MICHIGAN
APR 7 1953
EAST ENGINEERING
LIBRARY

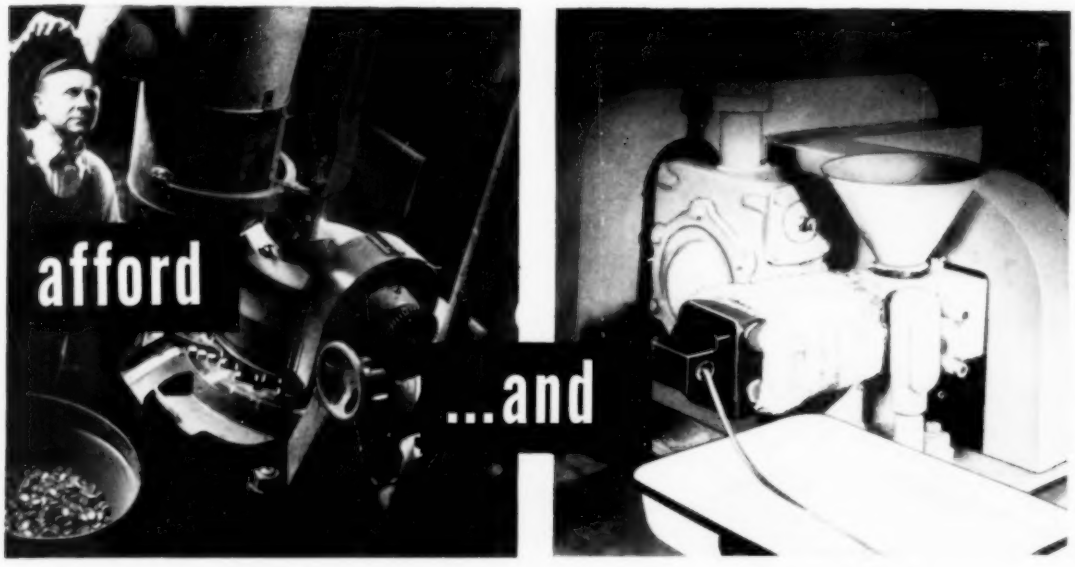
JOURNAL

VOLUME 9 NUMBER 3 • MARCH, 1953



A new use for the standard medical hypodermic syringe—cementing together parts of a plastic model used for investigating effects of vibration on generators and other large electrical machines before the actual units are built. The "shot" of acetone and plastic cement is injected into holes drilled through both parts to be joined. This novel method helps insure a better job of fixing sections of the model which must withstand vibrations from the electromagnetic "driver" shown at the top of the plastic frame. Use of the plastic model is a technique developed by Westinghouse scientists to test any large complex machinery against the effects of vibrations where it is impossible to get such information by mathematical computation. Use of a model saves costly design changes in the actual apparatus.

METASAP* STEARATES



superior lubricants in molding compounds

outstanding thickeners for plastisols

Metasap Calcium and Zinc Stearates are unsurpassed as lubricants — in molding compounds, or when dusted onto surfaces of mold cavities. Molders using them eliminate preform delamination, and breakage of finished products, because all *ejection pressures are minimized.*

If the importance of economy cannot be overemphasized in your compression molding, you'll find *nothing more profitable* than Metasap stearate lubrication. Metasap Calcium and Zinc Stearates will assure improved preforms, improved finished products, and increased output *at less cost.*

If you manufacture plastigels, look to Metasap Stearates. Not only have these quality metallic soaps proved *successful gelling agents,* but their *ready availability* and *basic economy* offer advantages you cannot afford to overlook. We'll be pleased to provide samples of —

Metasap Magnesium Stearate
Metasap Barium Stearate
Metasap Calcium Stearate
Metasap Aluminum Stearate

at no cost and without obligation, to help you select just the thickener, or thickeners, you find best for the plastisols you are handling.

*Reg. U.S. Pat. Off.

METASAP CHEMICAL COMPANY

For complete information, write

METASAP CHEMICAL COMPANY, HARRISON, N. J.

Chicago • Boston • Richmond, Calif. • Cedartown, Ga.

Stearates

of Calcium • Aluminum • Lead • Magnesium • Zinc

JOURNAL

Vol. 9 March, 1953 No. 3

Published monthly except July and August by the

SOCIETY OF PLASTICS ENGINEERS, INC.
513 SECURITY BANK BUILDING
ATHENS, OHIO

Dr. Jesse H. Day, Editor

Editorial Advisory Board: CARL J. FROSCH, ALLAN HUTCHINGS, MARIO PETRETTI, WAYNE PRIBBLE, GORDON THAYER, EDWARD VAILL, A. J. WARNER.

30 cents a copy **$3.00 a year**

Entered as second-class matter at the Post Office at Athens, Ohio.

Copyright 1953 by the Society of Plastics Engineers, Inc.

INDEX

ARTICLES

Principles of Plastics Screw Extrusion—W. L. Gore ... 6
Operating Characteristics of Extruders—J. F. Carley ... 9
Design of Screws for Polyethylene Extrusion—J. M. McKelvey ... 12
Multi-Screw Extrusion of Rigid Vinyls—S. H. Greenwood ... 20
Plastics in Surgery—Albert Lightbody ... 23
Metallization of Plastics—Harold Narcus ... 26
Plastics Problems in Electric Motors—Otto Wulfert ... 30
Plastics Literature in Government Reports—James Kanegis and Irvin Wolock ... 36

FEATURES

Szantay of Santay—M. A. Self ... 35
The Injection Molderscope—A. R. Morse ... 46
Plastics Around the World ... 42
News of the Sections ... 47

ADVERTISERS

Bakelite Co., Div. of Union Carbide and Carbon Corp. ... 5
A. Bamberger Corp. ... 56
Barrier-Pribble and Co., Inc. ... 56
Industrial Manufacturing Corp. ... 56
Injection Molder's Supply Co. ... 53, 55
Manco Products, Inc. ... 51
Metasap Chemical Co. ... 2
Newark Die Co. ... 19

The Society of Plastics Engineers Journal is not responsible for the views expressed by individual contributors. Copy for each issue should be received at The Security Bank Bldg., Athens, Ohio, before the 25th of the preceding month.

Across the Editor's Desk

● Your editor sees a lot of mail in a month, and glances through a number of the foreign plastics magazines as well. First thing to catch our eye was an ad in a French magazine for an injection machine with a capacity of 12 kg per shot. Taking my slide rule in hand, and translating, that comes out about 25 pounds! For comparison, the 300 ounce machine shoots about 19 pounds. Sounds mighty big to me!

● Looking a little farther along, there was a letter from Italy, which we wondered about for a few minutes and then decided to print in full in this column.

● Last issue carried an article on the electrostatic properties of plastics, and would have carried picture of the

---

YOUNG TOOL ENGINEER—Are you looking for a real future with an established firm with an outstanding reputation? We want a smart aggressive man to work in the mold design and expediting branch of our Engineering Dept. Experience in the plastics industry is not essential but knowledge of drawing practice and tool making is important. Opportunity for advancement is excellent. Write or telephone Superintendent of Personnel, Boonton Molding Co., Boonton, N.J. Phone—Boonton 8-2020.

PLASTICS ENGINEER

Diversification of extruded Thermoplastic products line by well-established company located New Jersey metropolitan area creates excellent opportunity for man having some experience with rigid vinyls. Primary responsibility will be research and development. Please submit complete resume for prompt and confidential consideration to box # 1453, SPE Journal, 513 Security Bank Bldg., Athens, Ohio.

EXECUTIVE AVAILABLE. Presently employed as Plant Superintendent of a medium size plant. Graduate Chemical Engineer; 24 years experience in Compression, Transfer and Injection molding, including all supplementary and finishing operations. Well versed in Development and Production Methods, Personnel Management, Cost Control, etc. Desires permanent position offering greater opportunities to use the accumulated experience. Married and in excellent health. Highly qualified references available.

Box 1553, SPE Journal, 513 Security Bank Bldg., Athens, Ohio.

FOR SALE—VERY CHEAP—5 INJECTION MOLDS PLUS A GOOD QUANTITY OF COMPONENTS. MOLDS ARE FOR A 5" ROUND COMPACT—A FLAT CIGARETTE CASE—A SQUARE CIGARETTE BOX—A PIANO CIGARETTE BOX AND A 16 CAVITY MOLD FOR MIDGET WIND-UP CARS. PRICES AND ADDITIONAL INFORMATION UPON REQUEST. Box 269, Dept. W, Erie, Pa.

Across the Editor's Desk

(continued from page 3)

authors too, but the engraver was a little too slow. So herewith we remedy that fault, and give you an opportunity to see authors, Ward T. Van Orman and Herbert A. Endres, who have been members of the Cleveland-Akron section of SPE for close to 10 years now.

Ward T. Van Orman

Herbert A. Endres

● Forty-three years in the plastics business is long enough to learn something about plastics. Hence a salute to Clair J. Terrill.

Clair Jay Terrill, Chief Engineer and General Manager of the Harry Davies Molding Company for the past 16 years, has retired from business as of January 1, 1953. He has been in the molding business since 1910 — before the word "Plastics" was applied to the industry and has enjoyed the highest respect of the companies with whom he has dealt for his engineering ability, both electrical and mechanical, on designing of customer's parts. Throughout the industry he is known as one of the best men on mold designs for plastic applications and creative ideas. One and all in the industry extend to him best wishes for good health and happiness in his well earned retirement.

Clair J. Terrill

FROM ITALY

Gentlemen:—

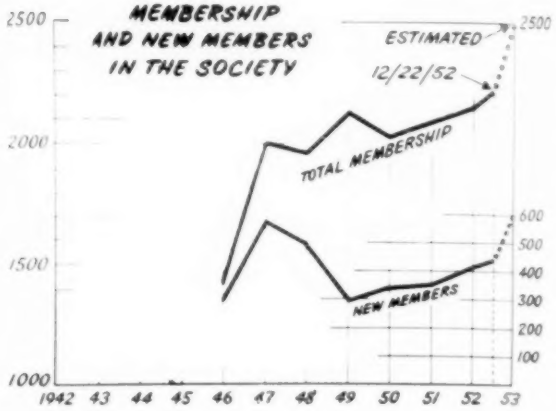
We should feel much obliged if you would, please, invite the interested members of your Association to submit to us, at their earliest convenience, well specified offers for the following machines, plastic materials and inks or colours in which we are interested to purchase.

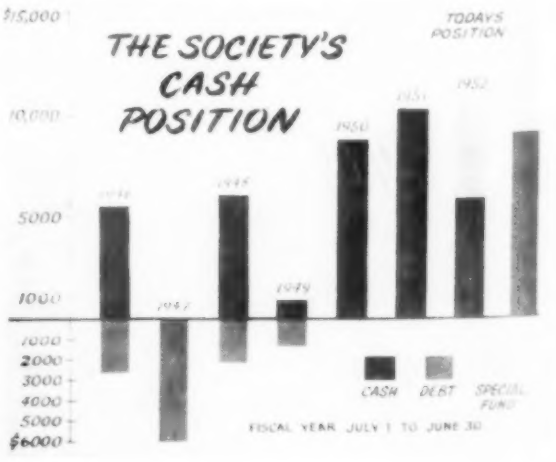
1) A complete up-to-date Plant, for medium size production, for making best kinds of Plastic Foils or Sheets of different sizes and thicknesses, especially suitable for Printing works and or for "plating" any kind of paper (as per enclosed samples) and for Covers of books, etc.
2) Polyvinyl or other kind of plastic materials suitable for making the said plastic foils or sheets.

(please turn to page 53)

Progress Report On SPE

From the Report of Retiring President
W. O. Bracken, Submitted January 1953





All tied up by a single market?

MAKE *FLEXIBLE* PRODUCTS TOO... WITHOUT ADDED INVESTMENT

Why be bound to one type of product, one market, when it's so easy to broaden your range! All it takes to get your share of the big, profitable flexible-item market is a change to VINYLITE Plastic *flexible* compounds. No extra equipment needed – these versatile materials can be fabricated easily on your present machines.

Look at these properties... imagine the product variety, the *new sales potential* you'll have!

FLEXIBILITY... to almost any degree, from soft and rubbery to semi-rigid... withstand long flexing without cracking.

COLOR... in practically every shade... in transparent, opaque or translucent form with lustrous finish.

DURABILITY... non-fading, abrasion-resistant... deliver extra-long service.

RESISTANCE... to oils, most chemicals, corrosive atmospheres, greases, water, alkalies.

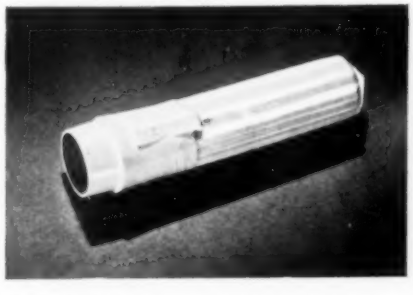
ADAPTABILITY... to high speed injection molding or extrusion. The temperature range for successful molding is highly flexible.

You need only glance at these properties to think of a dozen product applications. And there are hundreds more, with new uses constantly being found. It all adds up to a big, growing market – yours to sell without adding a dollar's worth of new equipment. Take the first step now! Get complete technical data, present applications of VINYLITE Plastic flexible compounds by writing for the illustrated booklet, "VINYLITE Resins and Plastics – Extrusion and Molding Materials." Address Dept. PD-43.

Vinylite
BRAND
PLASTICS

BAKELITE COMPANY
A Division of
Union Carbide and Carbon Corp.
UCC
30 East 42nd St., New York 17, N. Y.

LONG-WEARING feet, made by J. R. Clark Co. from VINYLITE flexible compounds are for ironing table legs. Non-skid, take rough handling and use. Molded by Minneapolis Plastics Corp., 366 Wacouta St., St. Paul, Minn.



FLEXIBLE CASE for flashlight, molded in one piece from VINYLITE flexible compounds. Heat-sealed, disposable unit is waterproof, tough, inexpensive. By Hungerford Plastics Corp., Rockaway, N. J.

UTMOST PROTECTION for tube and pipe ends and threads during shipping, storage, handling, is given by these tough, low-cost caps and plugs molded from VINYLITE Plastic flexible compounds.

Principles of Plastics Screw

W. L. Gore

W. L. Gore
E. I. duPont de Nemours and Co.
Polychemicals Department

Presented at the 9th SPE Conference

During the past 10 years the plastics screw extruder has become one of the most important devices for the fabrication of plastics into useful articles. In spite of the widespread use of these extruders, only very recently have we gained an engineering understanding of their operation (1) and as yet little application has been made of this information. The gain in efficiency by applying quantitative engineering to extrusion operations may be very worth while in many cases, and the methods for doing so are fairly simple.

THE FLOW COMPONENTS

A. Drag Flow

AN EXTRUDER CONSISTS essentially in a helical channel (the groove of the screw), one side of which (the surface of the cylinder) is sliding obliquely across the channel. This sliding action of the inside cylinder surface relative to the helical channel of the screw sets up a *drag flow* down the channel if it is filled with a liquid or granular material which can be sheared by the relative motion between the top and bottom surfaces of the channel. This drag flow is portrayed in Figure I. It is directed across the screw channel at right angles to the axis of the cylinder and screw. However, the thread of the screw acts as a dam set obliquely across the direction of flow, and diverts a portion of the drag flow down the screw channel. The geometry of a constant pitch, constant depth portion of a rectangular-thread screw is shown in Figure II. A study of this geometry leads to the equation for calculating the drag flow component along a screw channel:

$$(1) \qquad Q_d = \frac{\pi^2 D^2 N h \sin\varphi \cos\varphi}{2}$$

where: D = diameter of screw, inches
h = depth of thread, inches
N = rev. per sec. of screw
φ = angles of threads with screw diameter
Qd = cu. inches per sec. drag flow along channel

This drag flow component is the open discharge rate of the extruder if there is no die connected to it to cause a back pressure. It is obvious that variable pitch and depth screws will require more complicated formulas than this, but the open discharge of the common screw which has a shallow-depth metering section is well represented by this equation if the screw geometry of the metering section is used in the equation.

B. Pressure Back Flow

However when a die is attached to the extruder, a pressure is developed at the discharge end of the screw channel which causes a back flow which opposes the drag flow. If the channel cross section is slit-like (the thread depth less than about 1/10 the pitch of the screw), the effect of the sides of the threads in resisting back flow is negligible and the pressure back flow can be calculated from the equation:

$$(2) \qquad Q_p = \frac{\pi D h^3 P \sin^2\varphi}{12\mu L}$$

Where P = back pressure at the die
μ = "extrusion flow" viscosity of the plastic
L = effective length of the screw

This flow must be subtracted from the drag flow to give the output of an extruder against a given pressure. The effective length of the screw is that portion which is filled with melted material.

C. Leakage Flow

When a back pressure is exerted against the screw channel, leakage occurs across the tops of the screw threads due to the pressure differential across the thread. This leakage must also be subtracted from the drag flow to give the resultant output. The leakage is calculated from the formula:

$$(3) \qquad Q_L = \frac{\pi^2 D^2 \delta^3 P \tan\varphi}{10 e \mu L}$$

where: δ = the radial clearance between the tops of the threads and the cylinder
e = width of screw thread lands

The volume output of an extruder, Q, is then the re-

---

(1) A series of papers on extrusion theory was presented Sept. 18, 1952 at the ACS convention by W. L. Gore, R. A. Strub, J. F. Carley, C. H. Jepson, R. S. Mallouk and J. M. McKelvey. Publication of these papers is planned for the May 1953 issue of Industrial and Engineering Chemistry. The equations used in this paper were taken from this series.

Extrusion . . . . . .

sultant of the three types of flow:

$$Q = Q_d - Q_p - Q_L \quad (4)$$

The Screw Characteristic

If the screw of an extruder is rotated at some constant rate and the back pressure varied by changing the die orifice, the output-pressure relationship is called the screw characteristic. Figure III is a plot of this relationship. At zero pressure the output is equal to the drag flow of the screw. At zero output the maximum pressure is obtained. The screw characteristic is a straight line connecting these two points, provided the viscosity of the material and the effective length of the screw remain constant. A study of both actual screw characteristic curves and of equation 4 leads to the following observations:

1. Screw characteristic lines at different rates of revolution of the screw are parallel and their intercepts on the Q and P axes are proportional to the rates of revolution, (provided the temperature and viscosity of the plastic melt are not changed).

2. A flat line is obtained by using a shallow thread (small h), short pitch (small helix angle, ϕ), long screw (large L), or high viscosity plastic melt (high μ). A flat screw characteristic insures a very constant output.

3. The maximum output of an extruder operating at N rev./sec. with a back pressure equal to P is obtained when the helix angle ϕ is equal to 30° (pitch equal to approximately 1.8 D) and the thread depth h is set at:

$$h = \sqrt{\frac{3.56\,\pi DN\mu L}{P}} \quad (5)$$

However the output of this screw design is only slightly greater than one designed with the thread pitch equal to the diameter ($\phi = 18°$) and the thread depth set at:

$$h = \sqrt{\frac{6.18\,\pi DN\mu L}{P}} \quad (6)$$

(This is the condition when the pressure flow is equal to ½ of the drag flow and the leakage flow is negligible). The advantage of the 18° helix angle over the 30° is that most granular polymers appear to be conveyed forward from the feed hopper more efficiently with this smaller helix angle.

Scale up of Extruders

In general the scale up of extrusion screws should be in geometric proportion unless heat transfer is important. That is, a 4" diameter screw should be twice as long, have twice the thread depth, etc., as a 2" screw to handle the same material at the same temperature and at the same back pressure. At the same rate of revolution the output of the screws will differ by a factor equal to the cube of their geometric ratio (i.e. the output of the 4" extruder will be 8 times that of the 2" extruder). The power ratio will also be the cube of the geometric ratio.

In most extrusion operations, much of the heat to melt the plastic is generated by mechanical work in shearing the material, and only a minor proportion is transferred into the material from the hot cylinder. This is particularly true of large extruders where the surface ratio to throughput is unfavorable for heat transfer. The mechanical energy dissipated in the plastic is cal-

FIGURE I

DRAG FLOW BY SHEAR BETWEEN TWO MOVING SURFACES

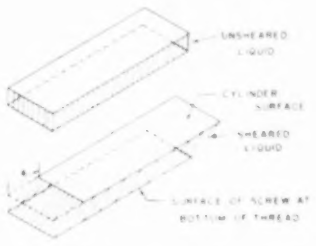
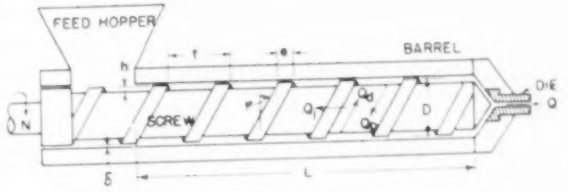


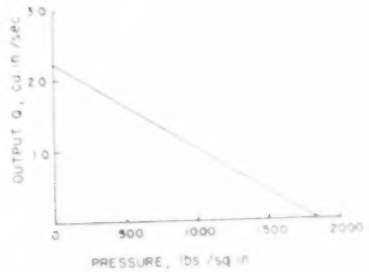
FIGURE II



SCHEMATIC DIAGRAM OF A SCREW EXTRUDER

FIGURE III

SCREW CHARACTERISTIC



culated from the horse power, Z, to revolve the screw at N rec. sec.

(7)

$$Z = \frac{\pi^3 D^3 N^2 \mu L}{h} + \frac{\pi^2 D^2 N\, Ph \tan \varphi}{2} + \frac{\pi^2 D^2 N^2 \mu' eL}{\delta \tan \varphi}$$

where μ = the viscosity of the plastic in the channel and μ' = the lower viscosity in the small clearance of the threads where the shear rate is high and consequently the temperature is increased.

To be useful, the power equation must be applied separately to each segment of the screw where the temperature and hence the viscosity are reasonably constant. Unfortunately we do not yet have good data for the viscosity of plastics, particularly under the conditions where a portion of the material is melted and unmelted particles are still present. A useful approximation is to calculate the heat necessary to melt the plastic and add the mechanical equivalent of this heat to that calculated from equation (7) for the melt end of the extruder to obtain the total power. The power required to melt the plastic will usually be much larger than that required in the portion of the extruder where the material has been melted.

Manufacturers of extruders appear to design their machines to scale up power and output by the square of the scale factor. This must be because they believe that heat transfer is the primary consideration in extruder capacity. It should be pointed out that most extruders, if insulated, will continue to operate with all heaters on the cylinder shut off, and often the temperature drop of the extruded plastic is surprisingly small.

Extrusion Viscosity of Plastics

In addition to screw dimensions and rate of revolution the viscosity of the plastic must be known in order to make useful calculation of extruder performance. By measuring the output of extruders and the pressure rise over the metering section under isothermal conditions for this section, "extrusion viscosity" values have been calculated using equation (4). For the few plastics investigated to date, this viscosity appears to check well with orifice flow viscosity where the average shear rate in the orifice is the same order of magnitude as the shear rate in the extruder channel. A great deal more work along this line is needed to provide "extrusion vicosity" data on all plastics.

Proposed Design for Multipurpose Screw

Obviously there is no single screw which will do ever an acceptable job on all plastics for all types of extrusion. However a screw stub with 3 or 4 interchangeable metering sections would cover a wide range of extrusion jobs. A proposed design for such a universal screw is shown in Figure IV. The characteristic of each of the four metering sections of a 2" screw operating at 1 rev./sec. are shown in Figure V for "Alathon" 1 polyethylene at 250°C, for HM 140 "Lucite" acrylic resin at 200°C, and for FM 10001 nylon at 280°C.

Future Developments in Extrusion

It is our belief that these ideas on the operation of plastics extruders are just the beginning and that they will be both refined and extended by extrusion engineers. Many innovations will be developed and the scope of fabrication by extrusion will be greatly enlarged. Some predictions may be challenging:

1. Extruders will be operated adiabatically, the temperature of the stock being adjusted by balancing the screw and back pressure by means of a valve between the die and screw.

2. Extruders will be operated at much higher rates of revolution of the screw and the output of these extruders will be determined by the available power rather than by the screw diameter.

3. Extruders will be built with large diameter screws at the rear and smaller diameter at the front of the extruder. The larger diameter feed section will insure that the solid material is picked up at a high rate, and also this will enable one to design screws to withstand high torque at the rear of the screw where torque stresses reach a maximum.

4. Extrusion molding will become the most economical process for forming thermoplastic materials into articles of both large and small size.

5. Thermosetting resins, pastes and plastisols will be formed by processes utilizing screw extruders to melt and/or to pump the material into molds.

These prophecies are based on the unique practicality of the screw extruder as a device for heating plastics by working them and on its efficiency and versatility in pumping viscous plastics melts.

If we are correct in our belief that extrusion will play an increasingly important role as the plastics age advances, it appears advisable for plastics engineers to study this process, both to increase their personal competence and to develop the process toward its ultimate potential.

FIGURE IV

MULTIPURPOSE SCREW

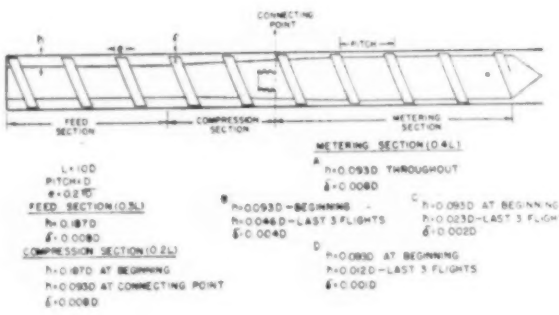
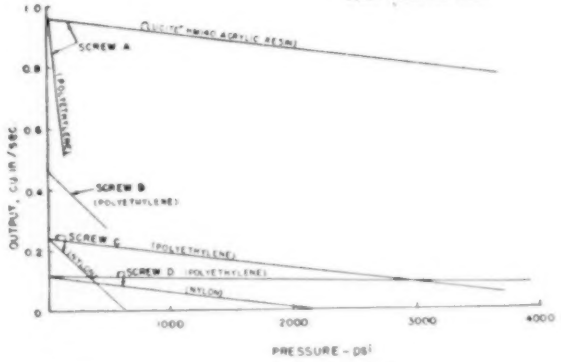


FIGURE V

SCREW CHARACTERISTICS FOR "ALATHON" 1 POLYETHYLENE AT 250°C "LUCITE" HM140 ACRYLIC RESIN AT 200°C NYLON FM10001 AT 280°C SCREW SPEED = 60 R.P.M.



Operating Characteristics of Extruders

J. F. Carley

J. F. Carley

E. I. duPont de Nemours and Co.
Polychemicals Department

Presented at the 9th SPE Conference

IN HIS PAPER MR. GORE has given you the basic reasons why an extruder works. In this paper I'd like to discuss the performance of real extruders, and how their performance fits in with these ideals.

Let me begin by reminding you that there are two kinds of jobs done by extruders. In the one class we have extruders whose sole job is to pump a melted polymer from a melt reservoir through a filter or a die. We call these melt extruders. The other class of extruders has a bigger job to do. Instead of being fed melts, these extruders are fed solid plastics, that is, strips or pellets or fluffy particles or granules of plastic or rubber. Their job is to take these particles and compress them, at the same time working them so much that they melt, then to force the melted plastic through smearing heads, screen-packs, and dies. We call these plasticizing extruders. In the forward section of a plasticizing extruder, where the pressure of the melt is being raised, we really have a melt extruder. In the section where the transition from solid to liquid occurs, we feel that by the time a fair proportion has been melted, the mass is acting much as a true melt would. In the rear end of the extruder the particles are moving in a way that has so far defied exact analysis, and our picture of what goes on there is not as clear and sharp as the picture we have of melt flow.

In the last paper, Mr. Gore gave some equations which were derived from our picture of what goes on in a melt extruder. It turns out that they are also very useful guide to the performance of plasticizing extruders, even though they may not apply exactly.

In considering the operating characteristics of screws, let's begin with a melt extruder. For the sake of simplicity, suppose that instead of a die we have a valve on the end of the extruder. Since we can open or close the valve as much as we please, the different valve settings will correspond to dies which offer different degrees of resistance to the discharge.

Suppose that we have such a set-up and that we are turning the screw over at some definite speed. Without changing that speed, let's make a number of valve settings. After making each setting, we will measure the production rate and the die pressure of the extruder. Now our theory says that if the valve is partly closed, the pressure should rise and the output should fall. If we made a graph of production rate plotted against the valve pressure we would expect that the rate would be greatest when the valve was wide open, and that it would be zero when the valve was closed. In the first figure I have made such a plot of data taken on a melt extruder which had a diameter of 5.5 inches, a pitch of 5 inches, and a thread depth of half an inch. From the flow equations, which were used to design this screw, we figured that it ought to deliver 1,000 pounds per hour of the melt at a pressure of 100 psi at a speed of 30 rpm. This graph shows the relationship between output and pressure at a constant screw speed of 30 rpm. The circles represent the actual numbers we got, while the line gives the values that were calculated from the theory. I think you can see that while these points are scattered a little, the agreement with the predicted value is good. Suppose now that we run this same extruder at different speeds. At each speed we will make various valve settings, and for each speed we

Figure 1

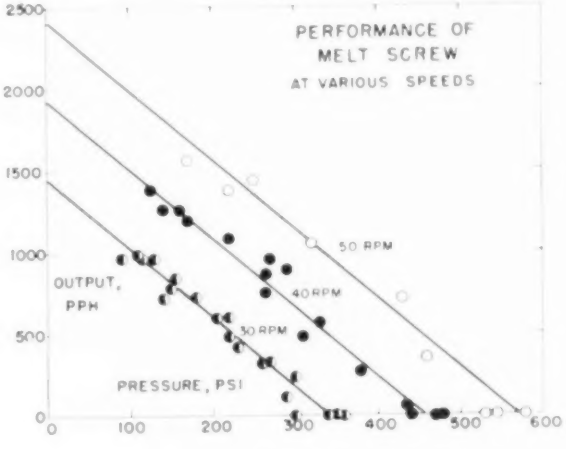


Figure 2

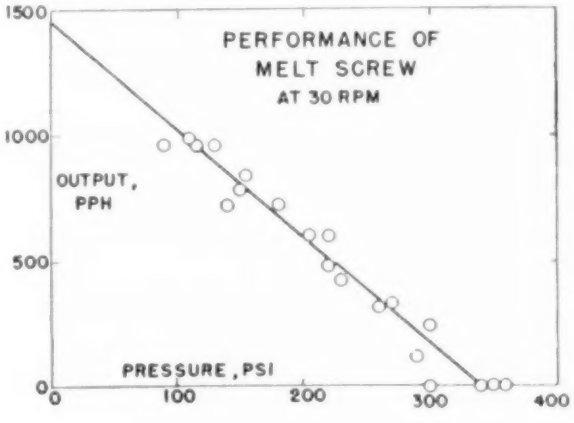
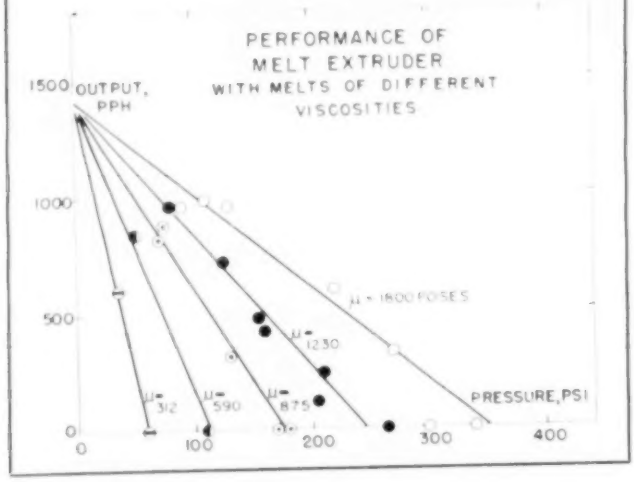


Figure 3



should get a line with the same slope as this one. But at higher speed we can naturally expect to get more out of the extruder, so the line will be located higher up on the graph. In the second figure we have plotted three of these lines on the same graph. The lowest one is the line for a speed of 30 rpm which you have already seen. The other two are for 40 and 50 rpm. Let's run up along the line representing zero pressure, at the left edge of the graph. The sloping line for 30 rpm intersects this vertical line at an output of nearly 1500 pounds per hour. This implies that for every 10 rpm of speed, we get almost 500 pounds per hour of output. So for 40 and 50 rpm, we should get a little under 2000 and 2500 pounds per hour, respectively. And we can see that this is actually what we do get. As we go to higher pressures, the output at any speed drops off, but since the spacing between the lines stays the same all the way down, the difference of 500 pounds per hour for 10 rpm is kept constant as the pressure changes.

What will happen to the screw characteristics, as these output-pressure graphs are called, if we change the viscosity of the melt? Remember that the back flow, which cuts into the production rate, is very much like the flow of any liquid in a pipe under a difference in pressure. You can imagine the spiral channel of the extruder screw to be a pipe with a rectangular cross-section. Now the resistance to flow in such a pipe depends on the viscosity of the liquid—the higher the viscosity, the slower the flow. So we expect that if the viscosity is raised, we will get proportionately less back flow in the extruder, and the production rate will go up. In the third figure we have plotted the screw characteristics for the same screw that we had before, run at a constant speed of 30 rpm, but with materials of different viscosities being fed.

The first thing you notice about this picture is that all the lines converge to the same point for zero pressure, and this is the same point we had on the other two figures for the 30 rpm screw speed—nearly 1500 rpm. This convergence to a common point tells us that the output at zero pressure is independent of the viscosity of the melt. This maximum output is called the drag flow or open discharge, and it was represented by the first part of the flow equation. If you were to refer back to that equation, you would find that the viscosity doesn't enter into that first part, but only becomes important when a pressure is generated. So these graphs have checked that point of the extruder theory. Now, as we said a moment ago, we expect that the lower our viscosity, the smaller the effect of output that we will get at a given screw speed and die pressure. The top line on this figure represents the performance of the extruder with a melt having a viscosity of about 1800 poises, and the lower lines are for successively lower viscosities. At the bottom, when the viscosity was only 300 poises, we can see that a back pressure of only 60 psi was enough to cut off the whole output of the extruder. With a viscosity of 1800 poises, represented by the top line, a back pressure of 60 psi reduces the output by only 10 percent, instead of 100 percent, as it did at the lower viscosity.

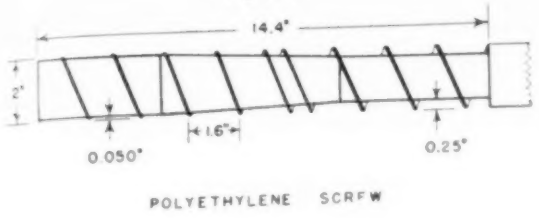
Let's stop here a minute and summarize what has been covered so far. We have found that the performance of melt extruders is accurately described by theoretical equations. And we have found that, once we have fixed the dimensions of the screw, the production rate increases with increasing speed, increases, but not proportionally, with increasing viscosity, and decreases with rising pressure. The fact that we have verified the theory so well with respect to speed, viscosity, and pressure is evidence enough that the rest of it is all right, too. But we have actually proved it out on many screws of different sizes and various thread depths, thread pitches, and thread widths. The equation for the power consumption has been fairly well proved by experiments. And since it arose from exactly the same considerations as the flow equation—there are really no new ideas in it—we can use it with confidence.

Let's think for a minute about a pair of extruders that look very much alike except that one is much bigger than the other. That is, the dimensions of the two screws are all in the same proportion—the little one is a scale model of the big one. Our equations show that if the big one is twice the size of the little one, then its production rate should be eight times as great, but it will generate the same die pressure. The big one will also use up eight times as much power as the small one. The practical value of these scale-up rules is this: we can use a small model extruder to tell us how a bigger, more expensive machine will work, before it is built.

Now these ideas that the output and power consumption should go up in proportion to the volume of the machine came from thinking about melt screws. But we have found that they also apply to plasticizing extruders, and it is plasticizing extruders which are most important to us.

What about the performance characteristics of plasticizing extruders? Do they follow the simple linear relationships that worked so well for melt extruders? The answer is sometimes they do, sometimes they don't depending on how well the rear end of the extruder supplies melt to the metering or melt section. Also, it is not easy to decide where in the extruder the melt section begins. But there is nothing to keep us from actually measuring output and die pressure. Also, we can calculate the maximum output at zero pressure, that is, with no die on the machine, since it is not affected by the length of the viscosity. Figure 4 is a sketch of a 2-inch diameter screw that was made for a Number 1 Royle extruder. The compression ratio in this screw is 5 to 1. The feed for this screw was polyethylene fluff, whose bulk density is about one-fourth the density of the extruded melt. We have found that the bulk density of fluff particles in the helical feed section of a screw is actually less than the density of the same fluff in a bag. Allowing for this, the compression ratio of 5:1 should be enough so that the feed section

Figure 4



POLYETHYLENE SCREW

will deliver as much melt as the metering section can pump out. Also, as you can see from the sketch, the feed was carried nearly two turns beyond the feed port before it was compressed at all. We consider this to be a good design because all parts of the screw complement the others. The shallow thread in the metering zone guarantees a rather flat characteristic, which means that rather large changes in the final pressure can be tolerated without much effect on the production rate.

We tested this screw in the Royle extruder, and we made some rather elaborate arrangements so that we would know just what went on during the experiments. The next figure shows the output-pressure characteristics of this screw at speeds of 15, 30 and 69 rpm. The points along the vertical axis are the maximum flows calculated from the theory. Each of the other points represents an operating condition during a day's running, after temperature conditions had leveled off. So these points are very firmly established. You can see that the slopes of these lines are nearly the same. The increase in slope as the speed goes up is due to an accompanying increase in temperature of 14 degrees centigrade. And from what we know of the change of polyethylene viscosity with temperature and shear rate, we calculate that these differences in slope are about what they should be.

The results on this 2-inch screw were so encouraging that we went ahead and constructed a 20-inch screw that was exactly similar to it in all respects, but ten times as large. Thus, we hoped to get about a thousand times the output from the big screw as we got from the model. Early reports on the operation of the 20-incher say that this is what we are getting; besides this, the melt temperature and pressure are about what we had predicted.

Not all screws behave as well as this one. It often seems that an extruder is not putting out what it should, judging from the dimensions of its metering section. Usually when we examine such screws a little more closely we find that some part of the screw is unable to keep up with the other parts. A common trouble is too little compression or not enough capacity for solid feed. Sometimes the capacity of the melt section is so great that the root diameter of the screw would have to be dangerously small in order to get enough feed capacity. McKelvey will discuss these points more thoroughly in the paper that follows this. Right now I'd like to present some data taken from a very complete study of the performance of a 2-inch extruder. This extruder was fitted with a type of screw which is sometimes called a "rubber screw." It has a constant channel depth of about four-tenths of an inch with large fillets at the root of the thread. The pitch is 2.5 inches at the feed end and it steadily grows less until at the last turn it is only 1.1 inches. The compression ratio of this screw is just 3:1. In Figure 6 we have plotted the performance character-

Figure 5

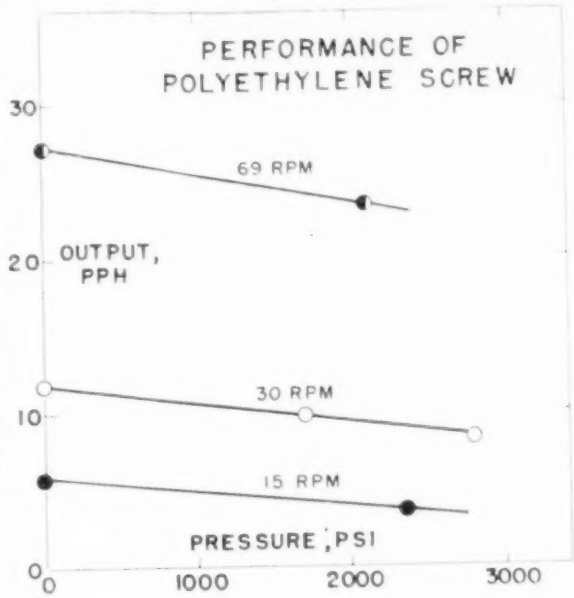
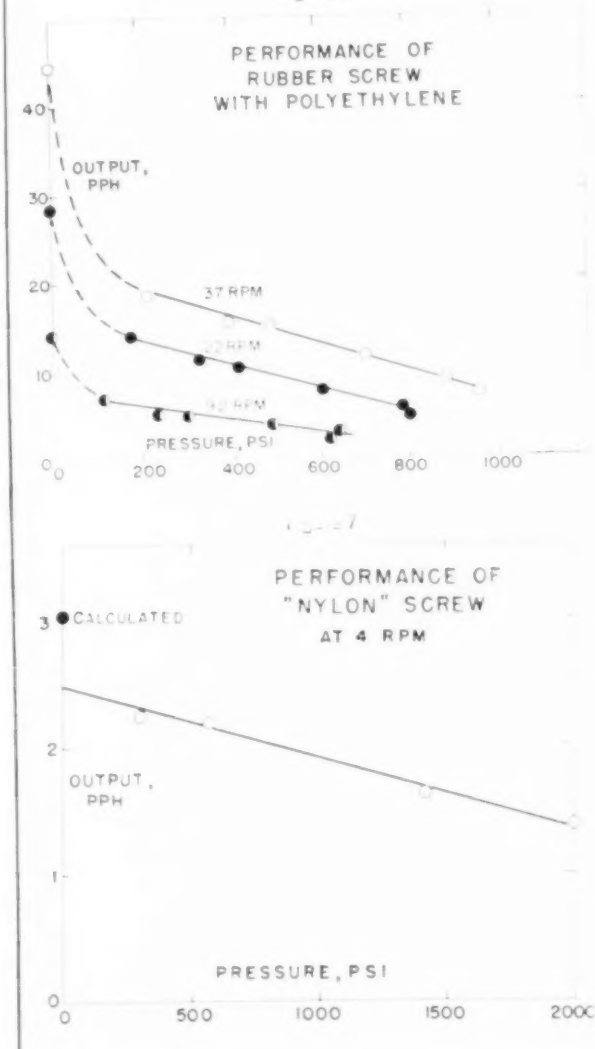


Figure 6



istics of this screw at speeds of 9.25, 22.2, and 37.0 rpm. They are certainly very different from the straight lines we have seen for other screws. At zero pressure we have much larger discharge than we have at even a small back pressure. We noticed when we pulled this screw immediately after each run that at the lower pressures, the solid polyethylene cubes were carried farther along the screw before they melted. As we decreased the die opening the pressure rose and most of the cubes melted sooner. At zero pressure about half the product consisted of unmelted cubes, while at 500 psi nearly all the solid was melted by the time it had gone two thirds of the way from the hopper to the die. Because of the very deep flights and constantly changing pitch, this screw has no metering section to speak of, and there is a sharp reduction in output with rising pressure. It's not an isolated case, by the way: we have seen the same general performance in the extrusion of plastics with other deep-flighted screws.

To wind up, let's look at the characteristic of a type of screw that has long been used for extruding nylon. This was a 2-inch screw having a constant pitch of one inch. In the first six turns of this screw the depth is constant at 5/16 of an inch; in the next six turns the depth is gradually reduced to 1/8 inch; and in the last six turns it is constant at that value. The overall compression ratio, when fillets are allowed for, is about 2.2 to 1. We extruded "Lucite" granules with this screw, and this compression is barely enough to compact the granules to the density of melted "Lucite." But the density of the granules in the feed section of a screw is even less than their density in the carton. When we allow for this, it looks as if the feed section of this screw might not be able to keep up with its metering section. In Figure 7 we have plotted an output-pressure characteristic for this screw. The line fixed by these points gives us an observed drag flow which is about twenty percent below the calculated value, indicated by the filled-in circle above. I'm sure a better design could be found for extruding "Lucite".

In the next paper, Dr. McKelvey will show you how these ideas, which have been sifted out of our study of extrusion, can be put to work in designing extruder screws.

Design of Screws for Polyethylene Extrusion

J. M. McKelvey

J. M. McKelvey

E. I. duPont de Nemours and Co.
Polychemicals Department

Presented at the 9th SPE Conference

IN OUR WORK ON EXTRUSION we have found it convenient to classify extruders into two groups, melt extruders and plasticizing extruders. In *melt extrusion* the plastic material enters and leaves the extruder in the liquid state. The extruder serves as a pump for the viscous liquid, building up enough pressure to force the material through the die at the desired rate. A common example of this type of operation is the melt spinning of nylon filaments. In *plasticizing extrusion* the feed material enters as solid granules or pellets and is compacted, melted, and forced through the die in the liquid state. Plasticizing extrusion is probably far more widely used than melt extrusion. This paper is concerned with the design of screws for plasticizing extruders.

The design of plasticizing extruders is a complicated business and we have found it convenient, in our thinking, to break up the extruder into its component parts. Then we consider the function and operation of each part separately, realizing, of course, that the operation of the machine as a whole can be no better than the operation of the weakest of its component parts.

Figure 1 shows a schematic diagram of a typical plasticizing extruder. I have chopped it up into five sections; the feed section, the compression section, the meter-

ng section, the working section, and the forming section. The function and operation of each of these sections will be discussed separately. On the same diagram I have sketched a curve which shows approximately how the pressure increases along the length of the screw and then falls again as the material flows by the torpedo and through the screen pack and die. The threaded portion of the screw serves two purposes; first, it compacts and melts the plastic material, and second, it builds up the pressure that is required to force the molten material past the torpedo and through the screen pack and die at the desired rate of production.

GENERAL CONSIDERATIONS

A. Feed Sections

The purpose of the feed section is to pick up the cubes or pellets of plastic from the feed hopper and propel them into the main part of the extruder. It is essential that the capacity of this section be at least equal to the desired capacity of the entire extruder.

We don't have a detailed mathematical theory for the movement of granular solids in the helical channel of an extruder screw, but we do have some experimental data which we use as a basis for our designs. The amount of any given material carried forward by the feed section of the screw depends, as a first approximation, upon the pitch and depth of the channel, the speed of rotation of the screw, and the diameter of the screw. We have carried out some experiments with polyethylene cubes in some very short screws and barrels so that we could make actual measurements of the amount of polyethylene picked up by screws. These experiments were run at room temperature with screws that had no compression ratio. The cubes were picked up at the hopper and then shoved out the end of the screw after one or two turns. We tested six 2-inch-diameter screws which had different pitches and channel depths. Experiments were run with each of the screws at 10, 20, and 40 rpm.

We drew the following conclusions from these experiments:

(1) In the range of 10 to 40 rpm, the speed of rotation of the screw had little effect on the amount of polyethylene picked up *per revolution*. In other words, for any given screw, the rate is directly proportional to the speed.

(2) The pick-up capacity of the screw increased as both the channel depth and pitch increased.

(3) The length of the feed port opening in the barrel also controls the amount of material picked up. The minimum length of the feed port opening should be equal to the pitch of the screw. If it is longer than this the capacity will not be increased, but if it is shorter than the pitch the capacity will be reduced.

From these experiments we obtained the pick-up capacities for 2-inch screws. In order to extend this data to larger size screws we applied the cube scale-up rule to them, which merely assumes that the capacity is proportional to the volume of the channel. In this manner we calculated the pick-up capacities of similar feed sections for larger diameter extruders. Figure 2 is a plot showing the results of our calculations. We have found this plot useful in our design work when we have to specify pitch and channel depths for the feed sections of screws.

B. Metering Sections

Now, for the moment, let us skip the compression section and look at the metering section. The purpose of the metering section is to take the molten plastic from the compression section and build up enough pressure to

FIGURE 1

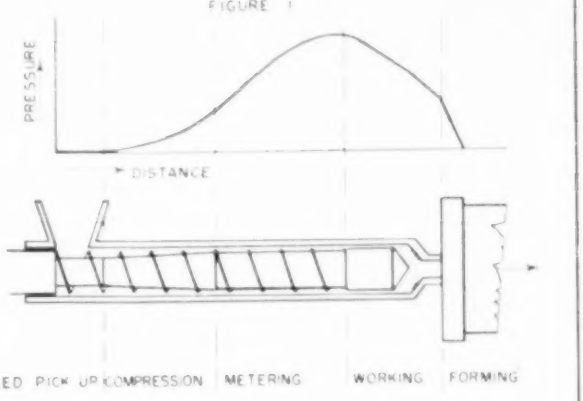


FIGURE 2

PICK UP CAPACITY OF FEED SECTIONS FOR POLYETHYLENE CUBES

T = PITCH OF SCREW

D = DIAMETER OF SCREW

h = CHANNEL DEPTH

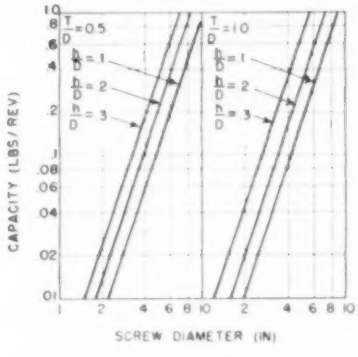
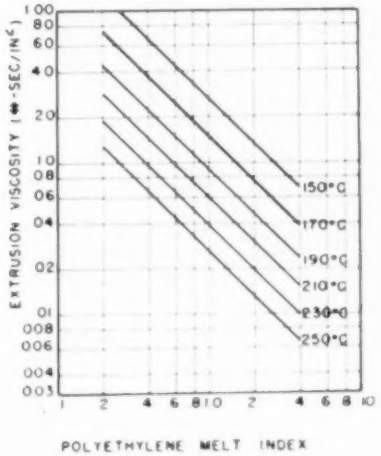


FIGURE 3

POLYETHYLENE EXTRUSION VISCOSITIES



force the melt past the torpedo and through the screen pack and die at the desired rate. The metering section acts also to smooth out irrgularities in flow caused by fluctuating pressures at the die or in the compression section. The design of the metering section naturally depends upon the nature of the processing job that the extruder is to be called on to do. For example, if the process specifications call for forcing the polyethylene at a very steady rate through a die which has a high resistance to flow, then the channel in the metering section must be quite shallow and the section itself must be long. On the other hand, if the material is being extruded through a large die which has a low resistance to flow, then the metering section can be shorter and the channel can be deeper and consequently the rate of extrusion can be higher.

The important thing about metering sections is the characteristic relationship between the flow rate and the pressure drop and the effect of the operating and design variables on this characteristic. The characteristics of metering sections can be calculated quite accurately using the extrusion flow theory which has been discussed in the previous papers. As an example of how the flow rate-pressure drop characteristic of the metering section is affected by the shape of the channel, I have calculated the characteristics of two different metering sections. For the plastic melt in this example I have taken an "Alathon" 1 polyethylene resin which has a melt index of 2. The extrusion temperature was taken at 170 C. In the calculation of screw characteristics one must have a value for the effective viscosity of the material. For polyethylene, as a first approximation, the effective extrusion viscosity depends upon the temperature and the melt index of the material. From our experimental work on polyethylene extrusion we have been able to construct a chart which gives polyethylene viscosities as a function of temperature and melt index. This is shown in Figure 3. At 170 C "Alathon" 1 polyethylene resin has an effective extrusion viscosity of about 0.05 # (force)-sec/sq. in.

Figure 4 is a sketch showing the two different metering sections which I have selected for this example. Both metering sections are 2 inches in diameter. The speed of rotation is 60 rpm. Section I is 8 inches long and has a constant helix angle of 20° and a constant channel depth of 0.075 inches. Section II is the same length and has a channel which is 0.225 inches deep. Its helix angle is 10°. Both of these sections have a land width of 0.1 inches.

Now, using the extrusion flow equation, we can calculate the pressure-flow rate characteristics for these metering sections. Figure 5 shows a plot of the characteristics. Knowing the process requirements it now becomes an easy job to select the type of metering section that will be best. For example, if we must operate at pressures above 500 psi and with a very steady output, then metering section I will give higher and more steady outputs. On the other hand, if we have a process where the die resistance is very small and we do not need a torpedo or screen pack, the pressure requirements will be low, and design II will give a higher production rate. Each processing job must be considered separately when it comes to designing the metering section of the screw. When the process specifications are known, then several metering sections can be calculated and the one which best fulfills the process requirements should be selected. The equations which are used to calculate these characteristics have been presented and discussed in the preceding papers.

FIGURE 4

METERING SECTIONS

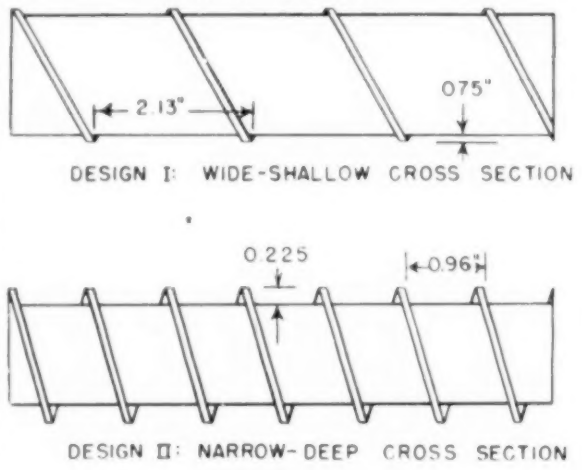


FIGURE 5

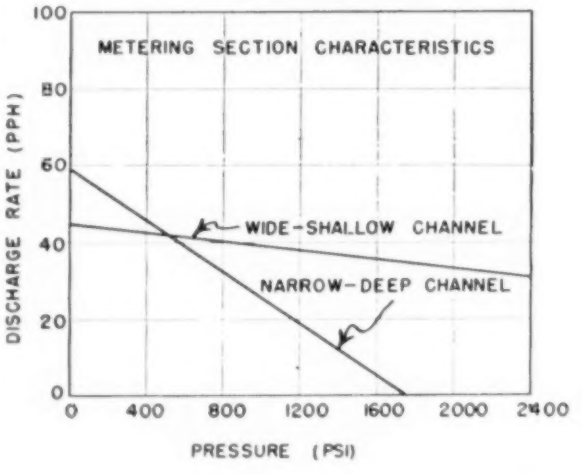
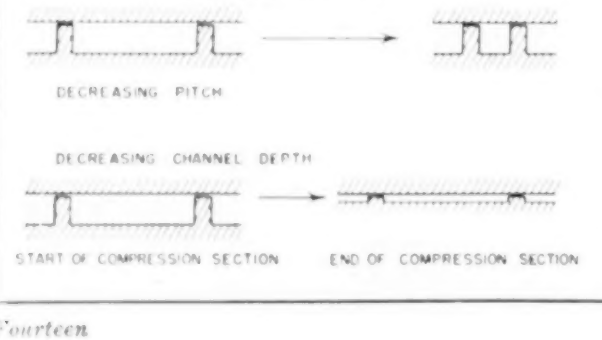


FIGURE 6

COMPRESSION METHODS



C. Compression Sections

The compression section connects the feed section to the metering section. Its purpose is to take the loosely packed pellets or granules of solid material from the feed section and to compact and melt them so that a continuous stream of molten plastic leaves this section to enter the metering section.

In the design of the compression section of a plastics extruder we are generally faced with three problems:

First, what is the compression ratio that is required, second, how do we obtain the compression ratio, and third, how long should the section be? I must admit that we don't know very much about the compression section. We have some ideas that we use in design, but as for any theoretical or experimental justification of them, all we can say is that so far they have worked.

Our thinking on the question of the compression ratio goes something like this: The plastic enters the compression section in the form of fairly loosely packed pellets or granules and leaves as a melt. Consequently there is quite a large decrease in the specific volume of the plastic and to prevent air spaces or voids the volume of the channel must be decreased a corresponding amount. Therefore we generally take the ratio of the melt density to the bulk density of the solid cubes as the minimum for the compression ratio. The bulk density of polyethylene cubes is, however, a function of the size and shape of the container in which the measurement is made. We have made several measurements in containers which are about the same size and shape as extruder screw channels and got densities lower than when we made the measurements in large drums. Therefore, for polyethylene cubes the minimum compression ratio is about 3 to 1 and generally we like to use at least 4 to 1.

The next question is then, how do we obtain this required decrease in the channel volume? Generally there are two ways we can do this. We can decrease the depth of the channel or we can decrease the pitch of the screw. Each method is commonly used. Sometimes we see a combination of both, but this is not very common. Is there any advantage of the one method over the other? As far as we know both work equally well in compacting and melting the plastic. The choice of which design is used depends mainly on the design that has been selected for the metering section. For example, we will generally have a helix angle of 20° to 30° at the feed section and will need about a 4 to 1 compression. Figure 6 shows the two ways in which we can obtain this compression. In the first method we reduce the pitch of the screw and end up with a nearly square cross section. In the second method we reduce the channel depth and end with a wide-shallow channel. For almost all applications the wide-shallow channel is preferable to the nearly square channel. In our previous example of the characteristics of different metering sections you will remember that the nearly square channel would be satisfactory only for a very low pressure operations. Certainly, when you must extrude past a torpedo and through a screen pack, the wide-shallow type of channel will be necessary. Therefore generally in our designs we obtain our compression ratio by decreasing the depth of the channel.

The length of the compression section is much harder to specify. Screws are generally designed with a length to diameter ratio of about 8 or 10 to 1. The length of the feed section of the screw should be about 2 diameters. This leaves a length of about 6 to 8 diameters to be divided between the compression section and metering section. We usually give about 60% of this length to the metering section and about 40% to the compression section.

D. Torpedo and Screen Pack

The torpedo and screen pack are not really part of the screw design, but they greatly affect the operation. Therefore it is very important to consider their function and purpose and to see what effect they have on the operation and design of the extruder.

The only reason for putting a torpedo or bullnose on the front of an extruder screw should be to apply mechanical work to the molten plastic. Since the torpedo imparts no forward motion to the melt, all of the material must be forced past it by pressure flow. This means that the screw is required to build a higher pressure when a torpedo is used and consequently, for a given production rate, a larger machine is required. Therefore, in considering a torpedo we must equate the possible beneficial effects of mechanical working against the increased cost of the design. A torpedo is capable of applying large amounts of mechanical work to plastics. However, there are many ways of applying mechanical work to plastics and total work added per pound of plastic is a poor criterion of effectiveness. For example, very high stresses can be applied for short periods of time or very low stresses can be applied for long periods of time and in each case the same amount of mechanical work can result, but the effect on the plastic may be vastly different. The torpedo, regardless of its design, operates at rather low stresses and unless it can be demonstrated that in the particular application low stress work will be beneficial to the plastic, a torpedo should not be specified.

The screen pack serves a different purpose. Its primary purpose is to act as a filter to strain out foreign particles that may have made their way into the plastic. A screen pack is often used also as a means of building pressure in the extruder, but it is our opinion that this is unnecessary and undesirable in a properly designed screw. We specify the minimum number of screens that will do an adequate filtering job for the particular application.

E. Power Requirements

The power required for the drive of a plasticizing extruder depends upon three factors: (1) the rate of extrusion, (2) the difference in temperature between the inlet stock temperature and the product temperature, and (3) the amount of heat that can be added to the plastic by heat transfer from the barrel.

We can make only approximate calculations of the amount of heat that can be transferred to a plastic in an extruder. For polyethylene extrusion we use an overall coefficient of heat transfer of about 40 BTU/hr-ft^2-F°. If we assume an overall temperature difference from the heating medium to the polyethylene of 100°C and that the extruder has a length to diameter ratio of 10 to 1, then we can calculate the total heat transferred to the plastic as a function of the screw diameter. Under these assumptions we obtain the formula:

$$H = 0.62\,D^2$$

where D is the diameter of the extruder (inches)
H is the heat transferred (HP)

The power that must be supplied by the drive is obtained by subtracting the transferred heat (H) from the total power requirement. The total power required depends upon the temperature rise of the polyethylene in the extruder and the rate of extrusion. Figure 7 shows a plot of total energy requirements versus the exit temperature of the polyethylene. We have assumed an inlet stock temperature of 20°C and neglected the pressure work term.

Let us take a couple of examples. First consider a 2 inch diameter extruder which is extruding polyethylene at a rate of 50 pph at temperature of 200°C. From Figure 7 we see that the total energy required is 0.11 HP hr #. Since we are extruding at 50 pph we need 5.5 HP total. The amount of heat that we can transfer is calculated to be 2.5 HP. The difference between these two is 3.0 HP.

FIGURE 7

POLYETHYLENE ENERGY REQUIREMENTS

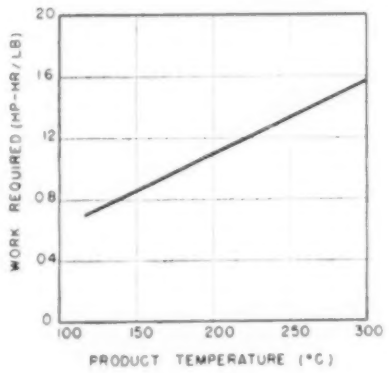


FIGURE 8

DIE AND SCREEN PACK CHARACTERISTICS

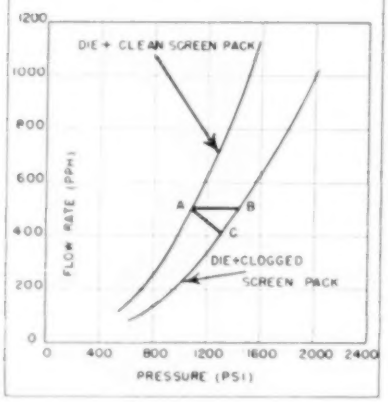
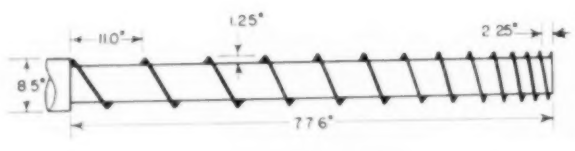


FIGURE 9

SCREW NO 1



DECREASING PITCH — CONSTANT CHANNEL DEPTH

Therefore, the drive must be able to deliver a net power of 3 HP to the screw.

Consider now an 8-inch extruder producing 1000 pph of polyethylene at 275°C. From Figure 7 we see that the energy required is 0.146 HP-hr/# giving a total of 146 HP. From our formula we calculate that we can transfer in about 40HP. Therefore, for this case we must supply 106 HP to the screw.

DESIGN OF A SCREW FOR A POLYETHYLENE FILM EXTRUDER

Now let us consider a specific design problem. The problem was to design a high capacity screw for the extrusion of polyethylene film with a No. 5, 8½ inch Royle through a screen pack and then through a sheeting die which has a slit opening 0.012 inches by 65 inches. When the machine was originally put into operation its production rate was in the range of 400 pph to 500 pph and the caliper of the film was maintained at about plus or minus 3%. The nominal operating speed was 35 rpm, and the polyethylene was extruded at about 275°C. About two years ago the operator wanted to increase the production of this extruder by about 50% to 650 pph. He found that the rate could be increased slightly if the screw speed were increased, but then the caliper of the film could not be maintained within the required limits. So, at that time a new screw was built for the machine. With this new screw turning at 60 rpm, the machine produced at the desired rate of 650 pph and the uniformity of the film was satisfactory. This rate, however, represents about the maximum that can be obtained with this screw under the existing process conditions. At the present time the operator wishes to increase the production rate of his machine to about 1000 pph, and we at the du Pont Experimental Station have been asked to assist in the design of a new screw which will produce at the 1000 pph level.

First, let us consider the pressure-throughout characteristic of the screen pack and the sheeting die. Fortunately, the machine has a pressure gage which is located between the end of the screw and the screen pack. This gage gives us the pressure that the screw generates, which is the driving force pushing the molten polyethylene through the screen pack and the sheeting die. Therefore, we have some points with which to construct a pressure-discharge plot for the combined die and screen pack. We know that for simple viscous liquids the flow rate is directly proportional to the pressure drop. Thus, for simple liquids a plot of throughput versus pressure would give a straight line on linear graph paper. However, polyethylene is not a simple viscous liquid. It is non-Newtonian and therefore does not have a linear characteristic. Experimental measurements show that, over limited ranges, polyethylene obeys an exponential flow law. This means that, if we plot the flow rate versus the pressure drop on log-log paper, we will get a straight line. By this method of plotting we were able to extend the range of the available data and construct the pressure-discharge characteristic for the combined screen pack and die. We get a series of lines because during the operation of the machine the screens become clogged which causes the flow resistance to increase and changes the characteristic. Therefore we worked out two characteristics, one for the clean screens, and the other for the screens when they are in their worst condition just before they are replaced. Figure 8 shows both of these characteristics plotted on linear graph paper. What happens to the operation of the machine as the screen packs become clogged? Assume that at the start-up with a clean screen pack, the rate

is 500 pph and the pressure is 1100 psi. This is shown as Point A on Figure 8. Now, as the screen pack becomes clogged, a higher and higher pressure is required to force the polyethylene through at the same rate. For example, if we wanted to maintain exactly the same throughput we would have to keep increasing the speed of the screw so as to build more pressure. Eventually we would reach the Point B where we would need a pressure of about 1440 psi. On the other hand, if we kept the speed of the screw constant our throughput-pressure relationship would follow a path similar to A-C on the diagram. The actual slope of A-C depends upon the screw design. In practice, the speed of the machine is usually controlled so that approximately the path A-B is followed and when the pressure rises too high the screens are removed for cleaning.

Now, let us consider the design of the original screw. Figure 9 is a sketch of this screw which we will call Screw No. 1. The depth of the channel is constant at 1.25 inches over the entire length of the screw. The length of the screw is 77.6 inches and the diameter is 8.5 inches. The pitch, which is 11.0 inches at the feed end gradually tapers down to 2-¼ inches at the delivery end. The pitch is then constant at 2-¼ inches for the last three turns at the delivery end.

At the feed pick-up end of the screw the ratio of the pitch to the diameter is 1.3 while the ratio of the channel depth to the diameter is 0.147. Using our chart of pick-up capacities we see that the estimated pick-up capacity of this screw is about 1 pound per revolution. Therefore, at a speed of 35 rpm the screw can pick up 2100 pph. The compression ratio of this screw is 6.4 to 1, which in our opinion is sufficient.

We were able to get some operating data for this screw. The control point for the product temperature was 275°C. Production ranged from 400 to 500 pph and the pressures from about 900 to 1400 psi. The nominal screw speed was 35 rpm, but actually ranged between 30 and 40 rpm depending on the condition of the screen pack.

We cannot make an exact calculation of the screw characteristic, since this calculation depends upon knowing how the viscosity changes along the length of the screw. However, we can calculate the drag flow rate, which is the theoretical maximum throughput at zero pressure, because the drag flow is independent of the viscosity of the material. This gives us one point on the pressure-discharge characteristic of the screw. We get a second point (440 pph at 1000 psi) by using the operating data. From this characteristic, which is for 35 rpm, the parallel characteristics for 30 rpm and 40 rpm can be constructed. Figure 10 shows these characteristics plotted along with the die characteristics. The intersection of a screw characteristic with a die characteristic is an extruder operating point. Due to the variable nature of the die and screen pack characteristic and the variable screw speed, there is not one operating point, but an *area* of possible operation. This area is bounded on two sides by the 30 rpm and 40 rpm screw characteristics and on the other two sides by the two die characteristics. We have also plotted on this graph the reported operating data of the machine. Most of the points fall within the area of possible operation or very close to it. Notice also that the output has been maintained by controlling the screw speed, so that the actual range of production falls within the 400 to 500 pph bracket.

Screw No. II which is currently in operation is considerably different from Screw No. I. Figure 11 shows

FIGURE 10

CHARACTERISTICS FOR SCREW NO I

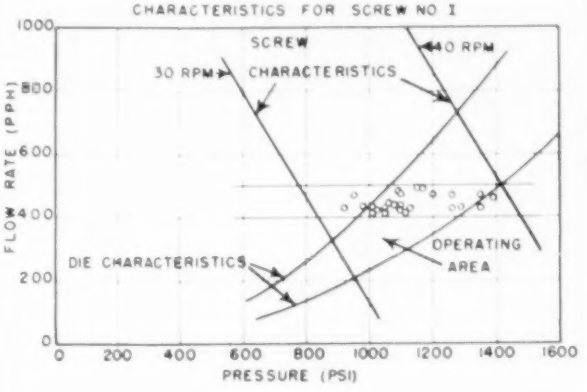
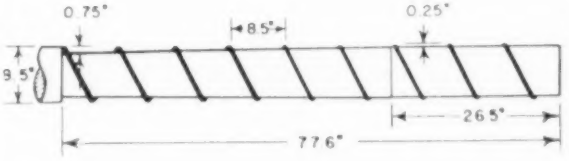


FIGURE 11

SCREW NO II



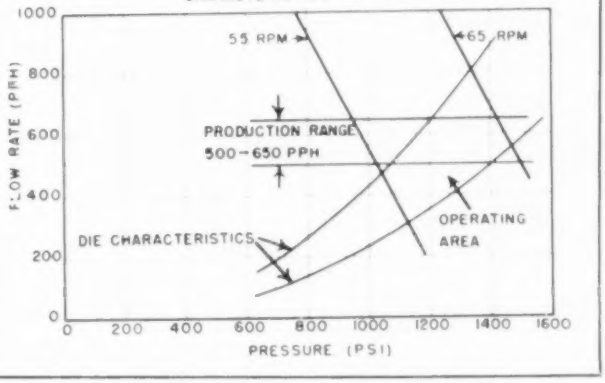
CONSTANT PITCH

CONSTANT DEPTH METERING SECTION

DECREASING DEPTH COMPRESSION SECTION

FIGURE 12

CHARACTERISTICS FOR SCREW NO II



a sketch of this screw. The length and diameter are the same as before, as the screw must fit in the same barrel, but now the pitch is constant at 8.5 inches over the entire length of the screw. The channel depth decreases uniformly from 0.75 inches at the feed end to 0.25 inches at the start of the metering section. The metering section of the screw consists of three turns having a total length of 26.5 inches with a constant depth of 0.25 inches.

At the feed pick-up end of the screw the ratio of the pitch to the diameter is 1.0 while the ratio of the channel depth to the diameter is 0.088. From our chart of pick-up capacities the estimated capacity of this section is about .75 pounds per revolution. Therefore, at 60 rpm this screw can pick up about 2700 pph. The compression

ratio of this screw is 3.0 to 1, which is less than what we like to use.

The polythylene temperature is controlled at 275°C. The production rate is in the range of 500 to 650 pph with the screw speed from 55 to 65 rpm. Pressures range from 1000 to 1500 psi.

FIGURE 13

$$Q = \frac{\pi^2 D^2 N h \sin\varphi \cos\varphi}{2} - \frac{\pi D h^3 \sin^2\varphi P}{12 \mu L}$$

$Q = 650$ PPH $= 6.50$ IN^3/SEC $h = 0.25$ IN

$N = 60$ RPM $= 1$ RPS $D = 8.5$ IN

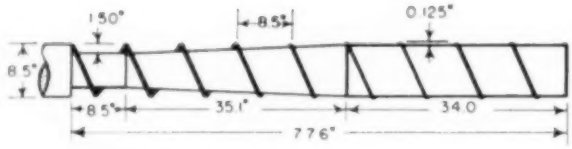
$P = 1000$ PSI $\varphi = 17.7°$

$$6.50 = 25.9 - \frac{3.86}{\mu L}$$

$$\mu L = 0.20 \text{ \#-SEC/IN}$$

FIGURE 14

SCREW NO III



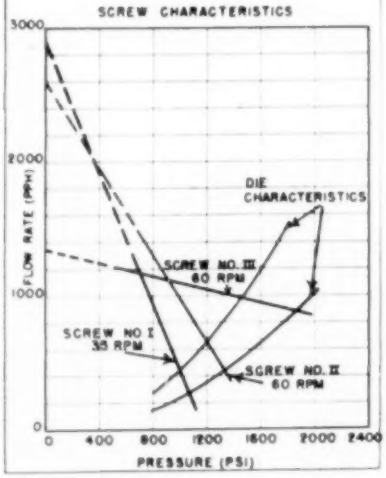
CONSTANT PITCH

CONSTANT DEPTH METERING SECTION

DECREASING DEPTH COMPRESSICN SECTION

FIGURE 15

SCREW CHARACTERISTICS



We established the screw characteristic for this screw in the same manner as we did for the other screw. Figure 12 shows the calculated screw characteristics plotted along with the die characteristics. Reported operating data for this screw generally fall into the calculated area of possible operation.

After studying the characteristics of Screws I and II it becomes apparent that for operation with "Alathon" 1 polyethylene resin at 275° both screws have characteristics which are entirely too steep. These steep characteristics give back flows which are much too large and consequently we get low production rates. For this type of application the wide-shallow type of metering section as in Screw II should be far superior to the nearly square type section that Screw No. I has. However, with the very fluid material and the relatively high pressures that we have to work against, the channel of Screw No. II is not shallow enough. By further reducing the depth of the channel we can cut down the back flow greatly and not lose too much drag flow, since back flow is proportional to the cube of the depth while the drag flow is proportional only to the first power of the depth.

The question is, how far should we reduce the depth of the channel in the metering section? We can calculate the new depth with the extruder flow equation, but first we must determine the two unknown quantities, μ, the average effective viscosity and, L, the length of the screw in which the polyethylene behaves as a liquid. Since Screw No. II is very similar to our proposed new design, we used the performance data for this screw to back calculate the product of the average effective viscosity and effective length. We calculated a value of 0.20# sec/in. Figure 13 outlines this calculation. We then used this value to calculate characteristics for the new screw. It turned out that a depth of 0.125 inches gave us about the best characteristic. Figure 14 shows a sketch of our new screw design. The characteristic for this screw is plotted in Figure 15 along with the characteristics for Screws I and II. This plot shows that with Screw III the throughput will be between 950 and 1050 pph with a pressure of 1400 to 1800 psi. Screw speeds will be between 55 and 65 rpm.

1000 pph represents about the maximum capacity for this machine if we stick to the present screen pack and die design. If we could change the screen pack and die characteristic by replacing the present screen pack with a smaller number of larger mesh screens we could further increase the capacity of Screw No. III. Figure 15 shows that an even larger increase in capacity could be obtained by operating Screws I and II at very low pressures. This could probably not be done though, because, with these screws, unless we have a relatively high pressure the polyethylene would pass through the machine without being uniformly melted. In other words, with Screws I and II there is probably a rather high minimum pressure that is necessary for any type of operation. We doubt very much if either Screw I or II would operate at pressures much below about 800 psi. On the other hand, Screw III could probably be operated down to almost zero pressure. At least, this has been our experience with similar screws of a smaller diameter.

We have calculated the power required for this screw using the general method that I outlined in the previous section. According to this method of calculation about 100 HP must be supplied to the screw. Allowing 25 HP for losses in the drive and motor the total power required would be about 125 HP.

Were awards handed out for excellence in moldmaking, it's safe to assume that Newark Die's famed master mold technicians would take the lion's share. These experienced experts who supervise the operation of Newark Die's modern Keller machines, Gorton duplicators, pantograph equipment, Blanchard grinders, precision lathes and heat treating equipment, are in charge of design and construction of all types of molds for the plastics industry.

Working as they do, in the world's largest, best equipped plant for plastics moldmaking, the Newark Die team is responsible for more plastics molds every year than any other single group. Their unmatched ability to produce the molds you want, when you want them, conforming precisely to specifications, should logically lead you to Newark Die for your mold requirements.

The Newark Die team

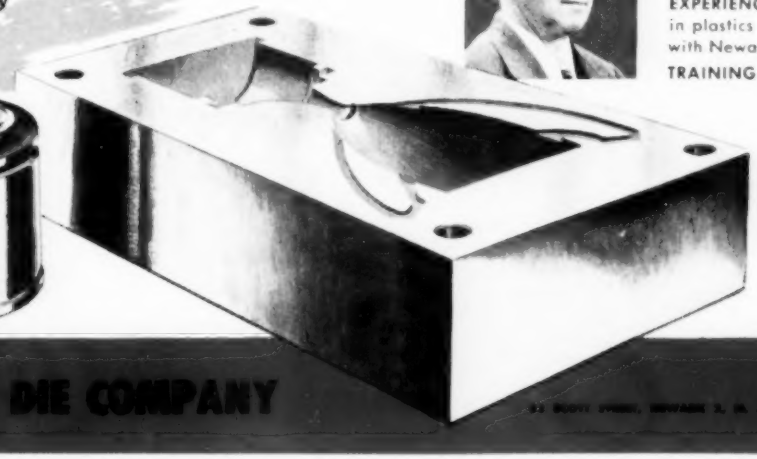
CHAMPIONS

in all

phases

of

mold making



G. J. SCHUSTER—*Plant Manager*

EXPERIENCE: tool and die making—33 years; in plastics industry—30 years; with Newark Die—30 years.
TRAINING: Fawcett Technical School.

W. J. TRAUTWEILER—
Chief Engineer & Sales Director

Associated with Newark Die for 16 years, most recently Superintendent of the Light Moldmaking Division, Mr. Trautweiler now heads the company's Sales, Engineering, Estimating and Customer Service divisions. Member of SPE and National Tool & Die Manufacturers Association.

ISLYN THOMAS—*General Manager*

Past National President of the SPE, Mr. Thomas is the author of numerous technical articles on mold design, hobbing and mold-making as well as the standard textbook, "Injection Molding of Plastics." He is one of the country's foremost authorities on plastics engineering.

E. W. SPITZIG—
Superintendent, Hobs and Cavities

EXPERIENCE: tool and die making—40 years; in plastics industry—26 years; with Newark Die—26 years.
TRAINING: Newark Tech.

HARRY TAYLOR—*Chief Estimator*

EXPERIENCE: with Newark Die—21 years; in plastics industry—21 years.
TRAINING: Newark School of Fine & Indus. Arts.

VICTOR P. BERGQUIST—
Superintendent, Moldmaking Division

EXPERIENCE: tool and die making—20 years; in plastics industry—18 years; with Newark Die—18 years.
TRAINING: Newark Tech.

M. G. WOHLLEBEN—*Chief Designer*

EXPERIENCE: in tool and die making—27 years; in plastics industry—17 years; with Newark Die—17 years.
TRAINING: Stuttgart Technical School.

NEWARK DIE COMPANY

Multi-Screw Extrusion of Rigid Vinyls

S. H. Greenwood

A contribution from Area III of the Professional Activities committee of the Society of Plastics Engineers

S. H. Greenwood

F. J. Stokes Machine Co.

Presented at the 9th SPE Conference

RIGID VINYL, as here discussed, consists of polyvinyl chloride resin, stabilizer, lubricant, and in many instances color pigment, but without plasticizer content. It is commercially available today in granular and preblended powder form. These materials are extruded into rods, tubes, sheets, channels, moldings and numerous other sections. It is the purpose of this paper to describe some of the more important techniques for rigid vinyl extrusion with the use of the meshed multi-screw extruders.

Some of the present applications for rigid vinyls include pipe for corrosion resistant service, insulating tubes and rigid sheets which are fabricated into fume hoods, ducts and tank linings. Polyvinyl chloride is also being used for hot water stand pipe service, in various gas installation service, and in sheeting for post forming.

A promising field for vinyls is pipe **liners** which can be extruded to slightly less than the inside diameter of the pipe they are to line, and are then mandrel-fitted to the pipe. In Orange County, California, a reinforced concrete sewer 35,000 feet long, consisting of 78, 48 and 39 inch pipe was lined with 4' x 8' PVC sheets locked into ridges as the concrete was poured, and the joints fused with a hot-air torch. One prominent manufacturer has 100,000 pounds of rigid PVC in oil pipe installations at this time.

It is conservatively estimated that the demand for rigid pipe, valves and fittings, and other rigid vinyl products including structural shapes will increase enormously within the next few years. CHEMICAL WEEK said in its issue of November 17, 1951, "with normal growth, structural shapes made of rigid PVC will be taking 100 million pounds of resin within the next five to ten years."

The following advantages for rigid vinyls may be noted:

(1) They are practically unaffected by all acids, alkalies and salts; by chlorine, oil, grease, alcohol and carbon tetrachloride. They are highly resistant to oxidation.

(2) Physical properties are good; the tensile often as much as 8600 psi, impact is 0.55 pounds per inch of notch, Izod, hardness Rockwell R-105 to 110.

(3) They will displace or replace several materials which are in short supply.

(4) Weight is light; only about ¼ that of steel, specific gravity about 1.4. This means that shipping costs are lower. Supporting members, though they must be closer together than supports for steel pipe, are substantially less in total weight.

(5) Resistance to heat is good, as compared with copolymer vinyls. Rigid vinyls will burn but are self-extinguishing when flame is withdrawn.

(6) Dielectric properties are excellent.

(7) Colors can be had in full range; also clear transparent for thin sections.

(8) Rigid vinyls are easily bent or formed by heating with hot-air gun. They can be machined, welded and cemented. Heat, butt or friction welding can be used. Molded fittings are available. There are also successful techniques which use solvent joining.

(9) They offer great possibilities for alloying with other thermoplastics to give a variety of physical properties though it is quite likely at a sacrifice of resistance to chemicals.

Current limitations are few, and will likely be less important as time goes on. Such as they are, they are here noted for the record:

(1) 170°F. is the heat distortion point.

(2) 300 psi is the safe limit for continuous operation for the following example pipe size—1" I.P.S.

(3) The co-efficient of expansion is several times that of steel.

(4) Rigid vinyls are swollen by aromatic chlorinated hydrocarbons, esters, ethers and ketones.

DESCRIPTION OF MESHED MULTI-SCREW EXTRUDER

The meshed multi-screw extruder has been found exceptionally well adapted for the extrusion of fully rigid PVC. The basic operating controls for this extruder are the three porportioning type pyrometers, one for the barrel temperature control, the second for the die adapter and the third for the die itself. The handwheel gives the manual control of the screw speeds so as to cover a

range from 6 to 18 RPM on the Stokes-Windsor RC-100, and this speed is indicated by the tachometer mounted on the front panel of the base. Manual controls are the feed regulator, and variable speed motor control. The latter, and the interrelated pulling mechanism are simultaneously controlled by the operator. The accurate control of these elements of the extruder is most important to successful operation.

Figure 1 shows two intermeshing screws. The two screws are divided into three sections, each with different diameters and thread pitch. The pitch of the mating flights on each screw is the same, permitting the screws to turn in the same direction without interference. The diameters of the three sections diminish from feed end to die end, while the root diameters increase. It is interesting to note that the tolerances between thread faces of mating flights and tolerance between the O.D. of the screws and barrel are only a few thousandths of an inch. The pitch varies in each of the three flights, the longer pitch lead being at the feed end.

The second photograph clearly shows the construction of the volumetric feeding unit. The unit is directly geared to one screw pinion. Therefore, for example, if the feeder is set at a =10 position any changes in screw speed will result in proportionate changes in feeding rates. The feeder is simple in operation and designed so that it can be readily dismantled for cleaning. A spring loaded safety clutch disconnects the feed drive if oversized particles of plastic should jam in this rotating, metering member. This design thereby eliminates any possible damage to the driving mechanism.

While water cooling of screw and or barrel is the generally accepted practice with single screw extruders, it should be noted that on multi-screw extruders neither the screws nor barrel are water cooled. Experience to date of processing rigid vinyls has indicated that water cooling of the barrel and screw is not required. Screws and barrel have been cored for water cooling for processing rubber and non-plastic materials where frictional heat build up has been excessive.

An interesting chart shows typical single screw extruders with estimated outputs and H.P. requirements and similar data for the multi-screw extruder is here given. This information has been taken from circulated literature of extruder manufacturers, and the figures shown are average figures for a number of different types.

Single Screw Extruders

Size	Output per hour	H. P.
$2\frac{1}{2}$	60-90	$7\frac{1}{2}$-10
$3\frac{1}{2}$	Up to 150	20
$4\frac{1}{2}$	150-350	40-50

Meshed Multi-Screw Extruders

Size	Output per hour	H. P.
RC-65	65	5
RC-100	100	10
RC-200	200	18

PRINCIPLE OF OPERATION

In principle the meshed multi-screw extruder operates like a constant volume pump.

A great advantage of the multiple screw is that the material in process can never seize to the screw and revolve with it as a unit in the barrel. The reason is that under the pressure of two or more series of intermeshing flights revolving in the same direction the material **must** flow from one to the other plane of the flights and must go forward. To bind, to revolve with the screw as a unit, to back up . . . any of these is an impossibility.

The positive displacement principle of the extrusion screw themselves coupled with a volumetric controlled feeder results in a uniformity of delivery of material from the die orifice which gives close dimensional control of the extruded article. Pulsation is reduced to a minimum.

The intermeshed screws also give excellent compounding and fluxing action. Some operators are using the meshed multi-screw extruder for compounding and pelletizing rigid vinyl preblend (powder) in preparation for the extrusion of rigid shapes. Though there is considerably more work to be done, the present indication

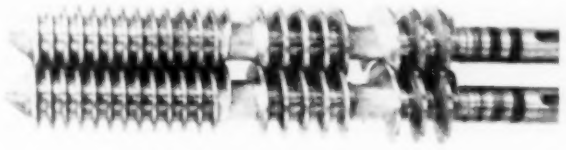


Fig. 1 Intermeshing screws for rigid vinyl extrusion.

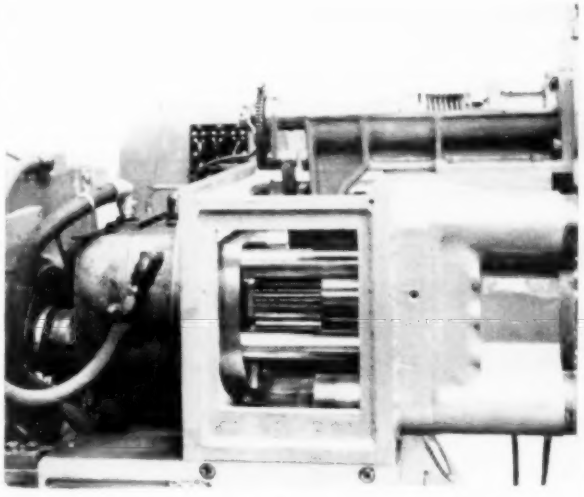


Fig. 2 Volumetric unit, directly geared to one screw pinion. Feeder is designed for easy cleaning.

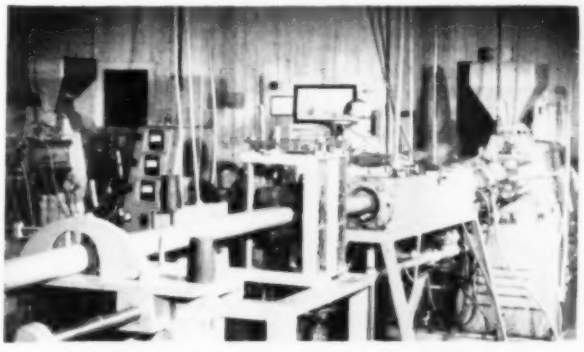


Fig. 3 Extrusion take-off equipment, showing 10 foot cooling tank.

is that with further refinements in extrusion techniques and possible formulation changes, extrusion direct from unplasticized PVC (powder form) is feasible on this type of equipment. This will mean, of course, that Banburys and mills will not be required. Only modest in-plant preblending equipment will be required to this job. These factors are excellent incentives for this type of development work to be carried forward at an accelerated pace.

Meshed multi-screw extruders are being successfully used with plasticized vinyl preblended formulations where the compounding, color dispersion and final extrusion is done in a single pass. It is these results, coupled with considerable laboratory extrusion of fully rigid preblended materials, that leads to the above conclusion.

It was noted earlier that for the RC-100 extruder (nominal rating of 100# per hour output) that only a 10 HP motor was required. The reason for this is the high efficiency as expressed in terms of volumetric displacement of the meshed screws. Another factor is that due to the lower RPM of these screws there is not the problem of frictional heat dissipation and the HP is actually being used to flux and propel the material forward.

One of the major problems in the extrusion of rigid PVC is to raise the extruder temperatures sufficiently to thoroughly heat the material and still avoid decomposition. The processing temperatures band is a relatively narrow one. This problem is minimized by the meshed screw extruder because the material is steadily and uniformly heated and forced through the barrel to the die at a controlled rate to assure complete compounding and fluxing and still avoid the decomposition temperatures.

It perhaps will be of interest to comment on another result of the inter-meshed screws. At the completion of a rigid vinyl extrusion run the screws are continued in operation after the feed is closed. This results in an almost complete purging of the screws and simplifies cleaning. Some present users have perfected their techniques to such a degree that upon completion of an extrusion run they are able to remove the die, the barrel and adapter plate, clean these members and the screws, then reassemble the machine all within a ten minute period.

Anyone who has been directly associated with extrusion knows the basic operator requirements for successful continuous production. I do not, in any way, desire to minimize the importance of well trained, competent extrusion operators. However, with the principles that are incorporated in the meshed multi-screw extruder it is a fair statement to note that personnel can be trained for this type equipment in a shorter period of time because of the relative simplicity of temperature and extrusion controls.

DIE DESIGN

Anyone experienced in extrusion work has ideas of die design based on his years of experience in this business. The following comments are based on observations that have been made in working with the multi-screw extruder. It is certainly true that the design principles for single screw extrusion dies are quite similar to that recommended for multi-screw extruders. Experience to date indicates that the following factors are extremely important. One of the foremost items is a great emphasis upon excellent streamlining of the die itself. Every effort should be made to design the die so there are no hold up points to create eddy currents or turbulent flow of the material being extruded.

Chrome plating of the dies for rigid PVC is highly desirable. This plating not only protects the contact surfaces of the die, but is also highly effective in transmitting a good finish to the extruded article.

It is important to design the die so as to have a gradually decreasing cross-sectional area from inlet to outlet of the die. It is important to eliminate any sharp angles. There is a gradual approach to the land section of the die itself. In one die the O.D. is 4.500 and the I.D. is 3.875, and the wall is .312. The ratio of land length to wall thickness is approximately 30 to 1.

S.A.E. 1020 type steel is used in the die referred to above. After the die has been completed and tested it is then case hardened to approximately C-62 Rockwell hardness and chrome flashed .0005". The internal section of the die is designed so that the mandrel and torpedo can readily be removed from the spider itself. In this way, interchangeability can be obtained for various pipe sizes without the cost of building complete dies for each size.

The spider of the die has provision for introduction of air through one of the spiders, a passage for lead wires for the internal cartridge heater for the mandrel, and a drilled passage for a thermocouple to control the mandrel heat.

Most of the experience to date indicates that a breaker plate and screen packs are not required with the meshed multi-screw extruder on processing compounded (granular form) unplasticized polyvinyl chloride. However, when processing preblended (powder) material breaker plates and a screen pack are desirable.

The sizing of a rigid PVC pipe is currently being done by two methods; one, using a former box, and the other method using a swaging or sizing die. In the first method, air of approximately 3-10 pounds per square inch pressure is introduced through the die spider and

(Please turn to Page 55)

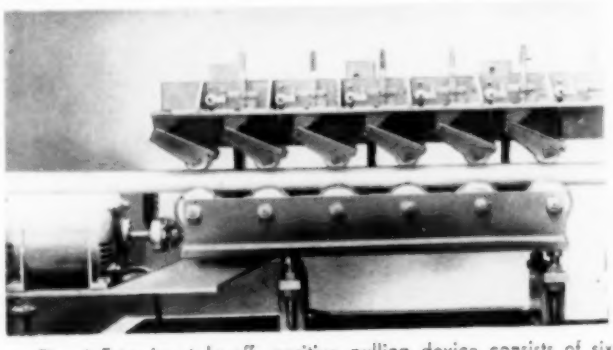


Fig. 4 Extrusion take-off, positive pulling device consists of six sets of traction rollers with medium soft serrated treads. Each wheel is driven from a common worm shaft.

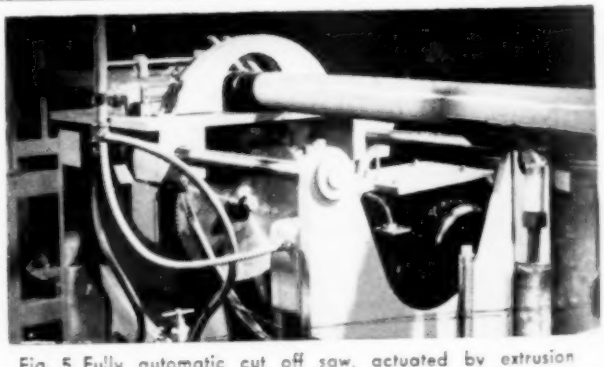


Fig. 5 Fully automatic cut off saw, actuated by extrusion pipe trips switch, giving full sequence of action. Clamp grips the pipe and saw blade moves forward for the cut.

Albert Lightbody

Plastics In Surgery

Albert Lightbody
Naval Ordnance Laboratory

Presented at the 9th SPE Conference

WHENEVER a new material becomes available to the general public you can be assured that the surgeon looks at it very critically for a possible application in his work. The surgeon is the expert repairman of the human body. As such he needs materials to make repairs or to carry out functions of the body in some new or improved manner. In plastics one has all the factors which would appeal not only to the public but to surgeons. The marvelous appearance of various types of plastics, such as found in lifelike dolls, may be obtained in flexible materials or rigid materials as the occasion demands. Plastics can be obtained which are very resistant to many of the corrosive fluids of the body and therefore have the permanence that is demanded of a repair part. In general, plastics are readily cleaned and have toughness which is also a definite requirement. Last but not least, it can be readily fabricated to meet the requirements of the surgeon.

IT is probable that the first surgeons in the field to use plastics to any degree were dental surgeons. We read that George Washington had wooden teeth fabricated for him. Now we find in all dental shops and dentists offices, plates, dentures and fillings, made of plastic. (1) While other materials have been tested, the plastics used in most of these have been limited to methylmethacrylate. They are easily kept clean, they can be colored to give excellent appearance and can be cast to the shapes that are desired. Some improvement is needed in materials to retain the shape of the original casting better. Dental surgeons were also instrumental in promoting the use of methacrylates in other places.

At the U.S. Naval Hospital in Bethesda the dental surgeons and plastics technicians in their group were instrumental in working out a plastic ocular prosthesis, in other words a plastic eye. (2) The advantages of these over the conventional glass eye have been noted in many publications. (3) Here the Navy has promoted the use of a molded item specifically to meet the needs of the patient. It requires a specific operation by the surgeon to leave a definite stump. A cast is then taken of the cavity and a molded methacrylate eye is prepared. That this type of prosthesis is effective can be demonstrated by photos or by actually seeing the patients. At one time at the Naval Hospital while walking down the hall with one of the dentists, he pointed out to me one of his patients. In calling him over to me he said "Can you tell me which of his eyes is plastic and which one is real?" and I think anyone would have had to admit that it was impossible to detect at even close range. This is due not only to the very lifelike appearance of the eye itself but to the fact that in cooperation with the surgeon it had been made possible to get the small eye movements which usually are the things that tend to differentiate the appearance of a real eyes from an artificial one.

Near the end of the war the naval hospital did considerable work on trying to make cosmetic parts for the body in order to improve the appearance and increase the morale of the patients. The laboratory at the Forest Glen extension of Walter Reed Hospital at Washington has done an admirable job in creating cosmetic prosthetic hands that actually work. The people in the plastics industry are acquainted with the work of Dr. Nelson who received an award as the winner of the medical science branch in the 7th Modern Plastics competition with his flexiderm cosmetic hand. The use of plastic served a dual role in this particular case inasmuch as the appearance of the prosthetic hand is such that it cannot be readily detected from a real hand and secondly that it actually operates. The original cosmetic hands were made with a mechanism similar to that used for the hook which had a spring, usually a rubber band, which could be opened voluntarily. When the spring closed it held the object to be picked up. The latest model of hands being made at the Army Prosthetic Laboratory under Dr. Leonard has a very ingenious mechanism enabling a more natural movement with the mechanism capable of closing voluntarily to the size that is required to actually meet the object which is to be handled. It also has an adjustable ratchet which enables it to be extended far beyond the normal range, but the mechanism, ingenious as it is, can still perform only a small portion of the functions of a real hand.

In the restoration of an ear the same type of material is used as in the cosmetic hands, vinyl plastisol, so that when it is molded in shape and adhered in place it is not at all readily discernible to the average observer. There are certain little tricks too that are used by the patient to hide the line between the real and the artificial part of the body.

One of the places where plastics was first used was in sutures in the sewing of incisions in the body. Many of you are acquainted with the nylon sutures which have been used for some time. There has been a lot of effort put into other types of sutures with the idea that they might be dissolved by body fluids after a time and therefore make the removal of the stitching unnecessary. At the Duke University Hospital some these materials which have been tried and have shown promise have been ma-

terials known as the bioplastics, which have as one of their components a polymer made from blood plasma. Another one which has shown promise is polyvinyl alcohol.

The use of a reinforced plastic has been a natural in many cases for artificial limbs. Its rigidity and light weight are extremely attractive. It is imperative in almost all types of plastic that they can be readily cleaned and do not absorb liquids. That is why some of the plastics actually are most important.

One of the most natural things to think of where plastics might be applied is in the bony structures of the body and here, as in almost every case you can think of, there has been a lot of experimentation. The Naval Medical Research Institute received considerable publicity a few years ago when they installed windows into the brain of two monkeys. This window was made of methylmethacrylate and enabled the researchers to observe the brain and the flow of blood in these animals during various external excitations. In another more usual application, after an operation on the brain, polyethylene was used by the Doctors Rubin, Robertson and Shapiro at the Kings County Hospital in Brooklyn. (4) This work has also been done in England using polyethylene as a bony member replacement in the skull, replacing the hard to get and expensive tantalum usually used in such operations. These same doctors in the Kings County Hospital have used polyethylene as a replacement for the cartilage in noses, ears and jaws as well as in the skull. A less unusual use is a protective piece put over a portion of the skull to protect the wearer from an accidental blow. This was done after an operation where a portion of the bony part of the skull had been removed. The tantalum plate had not yet been put in as drainage was still occuring so this unprotected part of the skull represented a potential danger inasmuch as only a small blow might cause death. Consequently the patient wanted a small device which could be worn comfortably with or without a hat and went away perfectly satisfied when this type of an arrangement was made.

Another replacement for bones occurs in the skeletons used for display and study, especially in medical schools. (7) One firm in Croyden, England is now manufacturing models of skeletons and selling these all over the world.

A truly remarkable job has been done by Dr. Hudack (8) of the Columbia Presbyterian Medical Center in New York City. His specialty is the repair of damaged or diseased joints. He has used plastics as the ball of the ball and socket joint and ingenious surgical techniques are used to tie the muscles into the plastic part. There have been many very unusual cases which Dr. Hudack has actually handled. At least one Navy veteran had a diseased right elbow which was removed and replaced by this combination of plastic and stainless steel. He can now write, shave and even scratch his head for the first time after his operation. He can even play ping pong. The selection of the materials to be used in this and other operations is dependent upon the reaction of the body to the foreign materials placed in it. The technique that Dr. Hudack has used has eliminated one of the big problems in trying to attach to a bone. As a rule if pins are put through a bone in order to anchor a member, resorption occurs in which the bone draws away from the foreign member placed therein and the result is a faulty joint. By placing the stainless steel prongs on the inside of the bone this does not occur. Dr. Hudack has tried other materials which he thought would do better due to greater strength or toughness but in most of these a foreign body reaction takes place which may result in infection or an abnormal cellular growth causing a deformity or crippling.

A problem which has bothered surgeons for some time has been the appearance of deformities which occur in the chest cavities when a lung is removed, or has collapsed for some reason, usually from tuberculosis. Work has been done in several places in trying to remedy this. (9) (10) (11) (12) One of the first to do work along this line tried the use of a vinyl bag filled with fiberglas. Dr. Allen Hurst, Medical Director of the National Jewish Hospital, Denver, Colorado, reports that 50 operations have been performed on TB patients where acrylic ping pong balls have been inserted into the chest cavity, sometimes as many as 100. In the same hospital and at the Mayo Clinic polyvinyl alcohol sponges which had been formalin treated have been used to do the same thing. It has been very popular due to the fact that it resembles actual lung tissue and can be shaped to fit the chest cavity quite readily.

Experimental work has been done in another instance where artificial kidneys have been tried. These parts of the human body carry on a very complex adsorption filtration whereby they rid the body of toxic materials and only a short disruption of this process may be fatal. At the Williams Buchanan Blood Center at the Baylor University Hospital (13) work has been done investigating ion exchange resins to do the same thing that the kidneys actually perform in the human body. Experiments with animals have shown that blood can be recirculated with only the artificial kidney for a few days. Work is still continuing to improve the capacity of the filter and to make the removal much easier.

Just a few months ago in the Washington, D.C. Evening Star an announcement (14) was made that Dr. Hufnagel of the Georgetown University Hospital had performed an operation on a 30 year old woman in which a plastic valve was inserted to take the place of a damaged heart valve. This particular valve was a ball valve made of methylmethacrylate in a tube about 1 inch long and about a half inch in diameter. It was inserted in the aorta just below the faulty heart valve. Dr. Zimmerman at the Naval Medical Research Institute several years ago did work along this same line in which a heart valve was installed in several animals. In the article in the Star it was reported by Dr. Hufnagel that 5 dogs had been living for three years with these plastic valves in their blood system.

The Hahnemann Hospital in Philadelphia (15) has used a Vanton squeeze action pump to take the blood from the large veins leading to the heart then purifying the blood by the removal of carbon dioxide and replacing it with oxygen in a stainless steel oxygenator, then returning this to the intake part of the heart. In almost all of these cases where blood comes in contact with plastic, clear methylmethacrylate has been used as it serves a dual purpose of being completely unaffected by the blood and also permits visual observation. In this mechanical heart-lung device used at Hahnemann the pump which simulates the heart is made of a Vanton squeeze action pump using a flexi-liner made of a pure surgical gum rubber and a block which was made of clear methylmethacrylate served the functions of the container in the removal of the carbon dioxide and oxygen.

An announcement has been made concerning the use of plastics disks (16) for sealing the ileostomy and colostomy appliances to the skin during operations on the small or large intestines. These are vinyl disks which are

moisture-proof, self-adhering and ready for use and have been developed by the Minnesota Mining and Manufacturing Company. The same company has experimented with the use of a sterile vinyl sheet for covering of an area prior to an operation. The incision is then made directly through the sheet and into the skin with no danger of infection from the surrounding area. A report has also been made on the use of a sterile polyvinyl chloride film to repair the lining of the cavity of the lungs. There has been a large amount of work done with polyethylene tubes for replacement of the various tubes in the body, such as in the gall bladder and bile ducts, where the plastics is exposed to fluids which are normally quite corrosive. They have also been used very extensively in repair of blood veins and arteries. ([5]) A use of the polyethylene tubing which is very common now is in the intravenous feeding. Considerable experimentation has been done whereby larger tubes have been inserted farther up into the veins where they are larger, permitting a more rapid rate of feeding. The rapid rate of feeding normally cannot be taken because this may induce a thrombosis blocking off the veins. However, if the intravenous solutions can be injected into a large vein which normally is not close to the surface a rate of feeding can be carried on which will enable a patient to be supported indefinitely by this type of feeding.

The television story of the recent AMA meeting in St. Louis showed the use of a plastic catheter being forced through the vein in the arm into the heart so that pressures in the heart cavity could be directly determined. The use of plastics in catheters is a very usual one. Vinyl ones and polyethylene ones have been standard for some time. Nylon has also been used for this application. In many cases it has been necessary to leave catheters in for some time and this indwelling of appliances has been carried out quite successfully with both vinyl and polyethylene plastics. ([18]) It is not unusual that liming or plugging up of the catheter occurs after a certain time within the body. However, this seems to be dependent upon the type of material used.

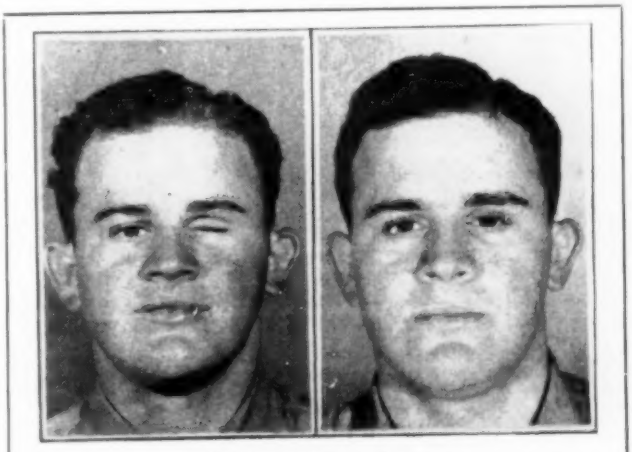
One can readily imagine that plastics can be used for splints and they have been because they can be formed to more nearly fit the body than normal wooden splints. The methylmethacrylate has been very commonly used for this inasmuch as its clear appearance, light weight and ease of cleaning make it quite adaptable. Typical of this is a finger support. Some reinforced plastics have also been used for this same purpose. The Walter Reed Hospital ([17]) has been using for over a year a Melmac orthopedic composition which is actually a bandage which has been dipped in a resin solution to which a catalyst has been added. The melamine composition then sets and ends up in a cast which is ⅔ lighter than plaster, porous enough to permit evaporation and thin enough to permit X-rays without difficulty. The finished cast is water and urine resistant and can stand several days immersion without ill effects. Other materials such as the polyesters have been tried for this same application but usually are irritating to the patient.

There are two chiropodists in Washington, D. C. who specialize in making arch supports to fit the feet using a reinforced plastic material. The success of this particular application is quite notable. One of my coworkers has been using these for several years now. He previously had difficulty with arch supports as even steel ones would break after a short time. Only after using the plastic ones which more nearly fit his feet has he found relief and at the same time has not found it necessary to have them replaced as often as before.

Plastics ear prothesis

Whenever any material comes in contact with the body either internally or externally there are many effects which may occur. It sometimes is shown by an irritation whereby the skin may become raw or rashes occur or it may cause excessive cellular growth. In many instances where this contact may occur over long periods, very minute quantities of material can cause either the irritation or abnormal body reactions. Consequently, the production of these materials used by the surgeon requires much more care than is normal. Hard rubber used to be used for large number of applications of the same type which have been described in this paper. However, the variety of materials which go into most rubbers cause great difficulty in actually procuring materials which are satisfactory for these purposes. Even in the plastics, one must be careful concerning the use of processing aids, antioxidants, plasticizers, mold release agents and any of the variety of small amounts of material which are normally added to either improve appearance, processing or ageing under most circumstances must be avoided. As a result it is not only necessary that the material which is being used must be sterile but they must also contain none of the materials which may cause difficulty when used within the body. As a result there are certain firms which have made material specifically for surgical uses in which a careful control of all of the materials going into the compounds is maintained. There are many other uses to which plastics can be put in the human body which I haven't covered. The use of artificial hair for wigs, the use of various types of braces which have been replacing metal, the use of polymers for replacement of blood

(Please turn to page 55)



Plastics ocular prothesis

Dr. Harold Narcus

Metalization of Plastics

Dr. Harold Narcus

Electrochemical Industries, Inc.

Presented at the 9th SPE Conference

The demand for commercial procedures for the metalization of plastics, which have become established upon their own merits in widely diversified fields, is increasing daily. Fortunately, the methods already in use and those in development have been able to keep pace with the rapid progress being made in the plastic industry itself.

The metalization of plastics has opened up a large new field in electrical engineering and electronics, e.g., electric insulation may require screening against magnetic fields, high frequency currents, or radium emanation. Articles made of plastics for these purposes, molded in phenolics or styrenes, which are excellent insulators, are plated with copper, cadmium, or lead. Such plated articles combine all the inherent advantages of the plastic and the required properties of the outer metal surface. We immediately see an important reason for metalizing plastics. The ultimate product may substitute one component for two or more others since the plated plastic article will retain its non-conductor properties and at the same time be in part a suitable conductor. This combination of a non-conductor and a conductor promises wide use in radio, television and in electronics in general. A most impressive example of such a combination is the manufacture of specially designed commutators, which demonstrates through selective plating, the ease with which intricate commutating surfaces can be obtained in depressed grooves in a molded plastic piece.

METALS SUCH AS aluminum and magnesium, although now more readily available, are being replaced by plated plastics in aircraft electric shielding and in radio shielding devices. The purpose of this procedure is to eliminate costly inserts and assembly operations to give a product which is lighter, more quickly fabricated, and much more resistant to the vibrations encountered in modern aircraft. This vibrational resistance was clearly manifested in a metalized plastic plywood antenna mast which was used in high speed fighter planes. This mast, which withstood the vibration of the plane at highest flight speed, was thickly plated with copper in some instances and with iron in others.

Another example of the metalization of plastics is in the manufacture of frequency modulation and television antennae. Their performance is thereby greatly improved, since the resulting reduction in weight permits a larger diameter tube or rod to be employed in the element, whereby an increase in surface area and consequently in pick-up is attained. The installation of metallized antennae is simple.

The deposition of metallic coatings on plastic substances permits the use of the so-called "scrap" plastic materials, which ordinarily could not be utilized without further processing. For example, mixed "scrap" plastics, of the thermoplastic type, of one chemical structure but of a different color, can be ground, remolded and then coated with metal.

The processing of metalizing plastics is not intended to imitiate metal but rather to yield a product that cannot be economically made of metal. More intricate shapes can be readily molded and plated than could be readily fabricated in metal and electroplated. As the weight added by the application of metal to the plastic is usually negligible, the metallized plastic part still maintains a weight advantage over a similar part made entirely of metal.

Soldering one metalized plastic component to another or to a metallic unit is now practicable. The process greatly improves hermetic sealing of such electric components as resistors, condensers and small relays, since non-metallic cases can be plated with a properly placed metallic band to be used for subsequent soldering to a metallic end cap, and insulators can be plated selectively and soldered to metallic containers.

One very important use of metalized plastics is the application of the various metals for decorative purposes. Numerous plastic items such as buttons, charms, and novelties have been made more appealing to the eye through this medium of metalizing.

Contrary to the beliefs of some, the cost of metalizing plastics, while somewhat higher than the cost of

conventional plating on metal, is low in comparison with the final cost of the metalized plastic part and of a similar part made entirely of metal and electroplated with a comparable deposit.

By plating on plastics, especially employing metallic coatings of the proper type and thickness, the undesirable properties of the plastics, such as absorption of oils, solvents and moisture, which may cause swelling or distortion of the basic organic material, are eliminated. The weatherability of the plastic is greatly increased. There is also an increase in tensile, impact and flexural strength and in resistance to abrasion and to distortion under heat.

Probably the outstanding advantage of metalizing plastics is the greater corrosion resistance of a metallic deposit when it is applied to a plastic material than to the usual metallic base. Resistance to salt water and industrial atmospheres is excellent since there is no electroplytic action. The inert, non-metallic plastic base insures a longer life of the outer metal coating and, hence, of the entire plated part.

Laboratory tests, using methods prescribed by the American Society for Testing Materials (Ref. 1) for physical tests on plastics, substantiates the foregoing statements, as shown in **TABLES 1 and 2.** (Reproduced from "Handbook of Plastics" by Simonds and Ellis by permission of the publisher D. Van Nostrand.)

METHODS OF METALIZATION

The most successful methods for the metalization of non-conductive materials, such as plastics, fall into three general classifications. Each presents certain advantages and disadvantages, depending upon such factors as size and shape of the item being processed, thickness of metal coating required, and the ultimate function of the coated article. Extreme brilliancy of the metallic coating also determines the method employed for metalization. The proper selection of the method used is most important in order to receive the greatest advantages from the metalized plastics.

At the present time, the aforementioned classifications are:

(1) Chemical reduction followed by electroplating
(2) Bright mirror-spray method
(3) Metal evaporation

CHEMICAL REDUCTION METHOD

The chemical reduction method, followed by electroplating, is perhaps the procedure most commonly employed in the metalizing industry today. However, its greater utilization is attributed only to the fact that there is a larger demand for the items which can be most economically and successfully processed using this method. This procedure embodies those methods in which a conductive film is formed by chemically reducing an aqueous solution of the metal salt with a suitable reducing agent. For example, a silver film is formed on the non-conductive surface, after its proper cleaning and pre-treatment, by reduction of an ammoniacal silver salt, such as silver nitrate, with formaldehyde.

It should be stressed that, with very few exceptions, the chemical reduction method is employed to render a plastic or other non-conductive surface conductive or current-carrying so that it will be receptive to subsequent electrodeposition. Electrodeposition must take place instantly upon immersion of the parts into the electrolyte,

TABLE I

Comparison Between Unplated and Plated Plastic Test Specimens

(Tensile, Impact and Flexural Strength)

Plastic Specimen (See Key)	Tensile Strength* (pounds per sq. in.)		% Increase	Impact Strength* (Notched Izod ft.lb. per in. of notch)		% Increase	Flexural Strength* (pounds per sq. in.)		% Increase
	Unplated	Plated**		Unplated	Plated**		Unplated	Plated**	
A									
(a)	9,525	10,500	10.2	0.33	0.40	21.2	14,000	16,775	19.8
(b)	7,750	9,000	16.2	0.30	0.38	26.6	12,000	14,500	20.8
B									
(a)	12,700	14,225	10.7	7.20	8.50	18.1	15,500	17,820	12.7
(b)	12,000	14,100	17.5	9.30	11.00	18.3	23,000	28,000	21.7
C									
(a)	9,225	10,525	14.1	0.52	0.65	25.0	11,500	12,750	10.9
D	7,500	8,775	17.0	0.28	0.33	21.4	12,000	13,500	12.5
E	6,500	7,250	11.5	0.24	0.31	29.2	9,500	10,750	13.1
F	9,250	10,125	9.4	1.00	1.20	20.0	7,500	9,000	20.0
G	10,050	11,250	12.0	1.10	1.30	18.2	13,000	15,000	15.4
H	6,775	8,650	27.7						
I	7,500	9,100	21.4	0.90	1.10	22.2	15,000	17,250	15.0
J	4,775	6,225	30.4	0.30	0.36	20.0	12,750	14,750	15.7
K	10,250	11,750	14.7	0.35	0.41	17.1	10,000	12,000	20.0
L	5,775	6,725	16.4	2.40	2.95	22.9	6,500	7,765	17.9
M	7,500	8,600	14.7	5.50	6.40	16.3	9,250	10,650	15.1
N	4,450	5,200	16.8	4.70	5.40	14.9	8,770	10,050	14.6

* Values given are averages of three test specimens.

** Plastic test specimens were plated with 0.0003 in. (7.6 microns) copper and 0.0005 in. (12.7 microns) cadmium.

Key to plastic materials

A—Phenol-formaldehyde (molding type).
(a) No filler.
(b) Wood flour filler.
B—Phenol-formaldehyde (laminated type).
(a) Paper base.
(c) Asbestos base.
C—Phenol-formaldehyde (cast type)
(a) No filler.
D—Urea-formaldehyde.
E—Melamine-formaldehyde.
F—Casein.
G—Vinyl chloride acetate.
H—Polyvinyl chloride.
I—Vinylidene chloride.
J—Polystyrene.
K—Methyl methacrylate.
L—Cellulose acetate.
M—Cellulose nitrate.
N—Ethyl cellulose.

whether it be barrel-plating or still-tank plating; even, continuous and homogeneous electrodeposits should result. This method eliminates the use of the older conductive powder-lacquer, metal spraying and other similar methods which possessed more disadvantages than advantages, except in certain limited applications. Generally, it can be stated that the chemical reduction method is employed for electroplating smaller items whose surfaces can be made conductive using bulk handling equipment, and such items which can be economically and efficiently electroplated in conventional barrel-plating units. Buttons, charms and other small plastic novelty items are good examples of products which are most often metalized in this manner.

Basically, the chemical reduction method involves the procedure of first slightly roughening or de-glazing the plastic surface using pumice-water rolling or blasting with aluminum oxide to insure mechanical interlocking of the metallic film and the subsequent electrodeposit; then cleaning the depolished surface; "sensitizing" the surface to promote better adhesion of the subsequent metallic film to the conductive surface; formation of the metallic film by chemical reduction; the electrodeposition of the intermediate layer of metal and, finally, the application of the outer, desired layer of metal.

The patent and trade literature reveals numerous formulations for carrying out this method of metalization. (Ref. 2-6.)

TABLE II

Comparison Between Unplated and Plated Plastic Test Specimens

(Distortion under heat and water absorption)

Plastic Specimen (See Key)	Distortion under Heat (°F)*		% Increase	Water Absorption in 24 Hours		% Decrease
	Unplated	Plated**		Unplated	Plated**	
A						
(a)	260	490	88.5	0.21	0.04	80.9
(b)	275	510	85.5	0.44	0.12	72.7
B						
(a)	320	470	46.8	3.5	0.12	96.5
(b)	370	490	32.4	1.9	0.10	94.6
C						
(a)	175	250	42.8	0.50	0.03	94.0
D	260	320	23.0	1.6	0.05	96.9
E	270	410	51.8	0.14	0.02	86.7
F	300	425	41.6	15.0	3.0	80.0
G	150	205	36.7	0.13	0.04	69.2
H	170	225	32.4	0.42	0.11	73.9
I	180	250	38.9	0.08	0.02	75.0
J	170	235	38.2	0.01	0.00	100.0
K	155	250	61.3	0.35	0.03	91.4
L	160	205	28.2	3.1	0.09	97.1
M	145	200	27.5	0.90	0.03	96.6
N	175	225	28.6	1.2	0.05	95.9

* Values given are averages of three test specimens.

** Plastic test specimens were plated with 0.003 in. copper and 0.0005 in. cadmium

(For key to plastic materials, see Table I.)

The advantages of the chemical reduction method are mainly the relatively low cost for processing small items without the necessity of employment of plating racks and subsequent polishing operations. The method is usually used when metallic coatings in the range from 0.0001" to 0.005" or even higher in thickness is desirable. Durability of the composite metal coating on the plastic surface is outstanding.

The main disadvantage of this method is the excessive costs involved when processing objects too large for handling in bulk equipment. The reason for these high costs is mainly the costs of hand-polishing operations to achieve a bright metal appearance. However, even in spite of the higher costs involved, this method is absolutely necessary if initial deposits over 0.0001" are required for certain functional purposes. There is no other available method for thick coatings other than electroplating unless a metal spray method is used and this is not too satisfactory. For application of bright metal coatings to plastics when the thickness of the metal is of no importance, the methods to be described shortly in this paper are preferred. Since these latter methods require no costly hand polishing operations, they lend themselves to the larger items requiring bright or even brilliant surfaces.

MIRROR-SPRAY METHOD

The mirror-spray method, specifically the application of brilliant silver films, involves the formation of the brilliant metallic film using a specially designed spray-gun. Specially formulated silvering solutions are sprayed simultaneously from this gun at the work, which has been properly prepared to receive the brilliant silver film. The gun may be so designed that the two solutions are internally mixed and sprayed at the work through one opening, or it may be so constructed that the silvering and reducing solution meet at a vortex a few inches from the point of the gun and hit the prepared work as a potentially silver film forming mixture. Here again, the trade and patent literature offers a multitude of procedures for carrying out this method. (Ref. 7-11.)

The fundamental steps for carrying out the mirror-spraying method when applied to plastic surfaces involve the cleaning of the plastic surface to remove mold release compounds, dirt or grease; application of lacquer to the plastic surface leaving the surface with a hard and glossy coating; "sensitizing" the lacquered surface to prepare it for silvering; application of the silver mirror using the specially designed gun previously mentioned and, finally, the application of a protective top coat of lacquer.

The main advantage of this method is the relatively low cost for equipment necessary to carry out the process. It is obvious that there is also a complete elimination of polishing or buffing operations to produce the desired brilliancy.

The disadvantage of this method is the extreme care which must be exercised in carrying out the procedure. The purity of the water used must be closely controlled. Cleanliness cannot be over-emphasized. The

process is also affected by temperature and humidity conditions which prevail at the time of spraying. An alteration of solution formulations is usually carried out to counter-act climatic changes. The process is only applicable to the deposition of thin, brilliant metallic coatings, but it has been also used to apply the conductive silver film to large plastic pieces prior to subsequent electrodeposition. In the latter case, lacquering of the plastic surface prior to silvering is not done.

METAL EVAPORATION METHOD

The third and last general classification of metalizing methods is the metal evaporation method. This procedure has attracted wide attention during the past few years and today is increasing tremendously in popularity. It is strange that, in spite of the fact that the principles of metal evaporation were known for many years, the process was not commercialized until the last few years. Recent advances in high vacuum engineering is probably the main reason for the sudden interest in this method.

This process, which resembles in principle the better known "cathode-sputtering" method, involves the deposition of brilliant metal coatings to non-conductive surfaces, utilizing the principles of the ease of evaporation of metals under the conditions of high vacuum. An impressive list of metals have been evaporated on numerous plastic materials under the proper conditions.

There are several technical articles appearing in the trade literature which describe this process for metalization of plastics and the techniques of both metal evaporation and its somewhat allied process of "cathode-sputtering." (Ref. 12-13.)

There are several companies manufacturing the equipment for properly carrying out this process.

The presently employed procedure for actually carrying out the process of coating by metal evaporation involves the steps, namely, cleaning of the plastic items to remove grease, dirt or mold release compounds; application of a suitable lacquer coating as in the silver spray method previously discussed; evaporation of the metal desired and, finally, a final or top coat of lacquer is then applied to the brilliant metallic film.

The main advantages resulting from the use of this metal evaporation process employing high vacuum techniques are:

(a) It offers a means by which brilliant, mirror coatings of any metal can be applied to plastics without the necessity of polishing operations.

(b) The process is adapted to the formation of brilliant coatings on the reverse side of transparent plastics giving special effects (reverse mirroring).

(c) No chemical processing solutions are necessary to carry out the process.

(d) Climatic changes are not so critical in this process as they are in the silver spray method.

The main disadvantages of this method are:

(a) The initial high cost of the coating and accessory equipment necessary to carry out the process, including jigs and fixtures which hold the items being coated, is an important factor.

(b) The durability of the final finish is entirely dependent on that of the top coat of lacquer. This is also an additional disadvantage of the silver spray method. In other words, if the top coat of lacquer fails—the finish itself will fail.

All the methods described in the foregoing pages can be successfully used for printed circuit techniques and supplement the numerous other methods utilized for this specialized type of work. (Ref. 16-17.)

MISCELLANEOUS METHODS

Included in this survey of commercial methods for the application of metallic coatings to plastics, it would be in order to mention other developments which have been used to some extent in the past and which have, during recent months, appeared on the horizon. Reference is made to the specially formulated conductive silver paints which are far superior in many ways to the old type conductive lacquers, to metal coating employing "gas plating" and the formulating of conductive plastics capable of receiving electrodeposits directly without prior treatment.

Conductive silver paints are commercially available which have well-served in the field of metalizing. They can be applied by spraying, dipping or brushing and are best employed where there is no detail on the part being plated.

"Gas-plating" promises a method that will greatly increase the rate of deposition for those metals which form volatile carbonyls, nitrosyls, hydrides, salts and metallic organics. The term "gas plating" refers to the deposition of metals on the surface to be plated by the thermal decomposition of these previously mentioned metallic compounds in an inert atmosphere. For example, the carbonyl gases of such metals as copper, iron, lead, nickel, chromium, tungsten and molybdenum have been used and studied extensively. (Ref. 14.)

Another recent development which already has found numerous applications in the electrical and electronic fields is the manufacture of a new class of conductive plastic materials which makes possible the molding of plastic forms exhibiting a wide range of conductivities. These electrically conductive materials can be molded and can be directly electroplated with the desired metal from the conventional electrolyte. (Ref. 15.)

BIBLIOGRAPHY

1. **Handbook of Plastics,** Simonds & Ellis, pp. 58-149 (1943).
2. **Metallizing Non-Conductors,** Samuel Wein, Metal Finishing Publishing Co. (N.Y.C.).
3. U. S. Patent No. 2,421,079.
4. U. S. Patent No. 2,454,610.
5. **The Electrodeposition of Metals on Plastics,** Harold Narcus, Trans. Electrochem. Soc., Vol. 88 (1945) pp. 371-387.
6. **Practical Copper Reduction on Non-Conductors,** Harold Narcus Metal Finishing (1947).
7. **Brilliant Silver Spray,** A. S. Langlotz, Organic Finishing, July (1947).
8. U. S. Patent No. 2,136,024.
9. U. S. Patent No. 2,214,476.
10. U. S. Patent No. 2,367,903.
11. U. S. Patent No. 2,363,354.
12. **Metal Coatings by High Vacuum,** Philip Godley, Iron Age, April (1948).
13. **Metal Coatings by High Vacuum Techniques,** F. C. Brenner, Electrical Manufacturing, March (1947).
14. **Gas Plating,** A Report to Industry, Commonwealth Engineering Company of Ohio Publication, June, 1949.
15. **Plastics Can Be Electrical Conductors,** Staff Report, Electrical Manufacturing, November (1949).
16. **Printed Circuits Technique,** Brunetti & Curtis, National Bureau of Standards Circular, 468, November (1947).
17. **New Advance in Printed Circuits,** Miscellaneous Publication, 192, November (1948), National Bureau of Standards.

Custom Extrusion Booklet

"Custom Extrusions in Thermoplastics" is a new **service** folder prepared by the Anchor Plastics Company which gives comprehensive information about the characteristics of thermoplastics. The folder discusses forms and shapes of extruded plastics and a general summary as to how thermoplastics may be used by industry. A properties chart is included which enables the manufacturer to see at a glance which themoplastic is most suited to his needs.

Also contained in the folder are useful data about the facilities and services of the Anchor Plastics Company.

This folder may be obtained by writing to Anchor Plastics Company at 36-36 36th Street, Long Island City, New York.

Otto Wulfert

Plastics Problems In El

Otto Wulfert

Wagner Electric Co.

Presented at the 9th SPE Conference

THE THEME of the SPE conference for this year—"Plastics-Engineered for Tomorrow" — represents the modern thought that plastic developments should be used when they fit the particular needs of a particular industry. This is certainly a better approach than the idea that plastics could be substituted wholesale for other materials as was the thought several years ago. Plastics should not be considered as a substitute, but should be used because of their superior quality and when they are the best and least expensive material that can be used. In many developments, it has been found that plastics are the only material that can be used.

The thought "Plastics-Engineered for Tomorrow" fits particularly well into the electric motor industry where it is difficult because of the established designs, established practices, customer acceptance, or just plain opposition, to make any change.

Sometimes it seems that the usual practice in the electric motor industry is to make no changes unless the present design is unsatisfactory. In many cases, it is almost apparent that a plastic material will answer the purpose and will certainly cost less.

The well established engineer will usually not consider a change unless the change provides a better construction and costs less. This does not, of course, apply if change is necessary because of difficulties. In this case, many times, cost is not considered.

The greater advantages in the use of plastics are usually very apparent to the prospective supplier or his salesmen and it is with the supplier and the salesmen that the electrical and mechanical designers have the greatest difficulty. The salesmen cannot understand why, if plastic has been found satisfactory for some organizations or for some purpose, it cannot be universally applied.

In the application of plastics to an established design, it is usually necessary to consider also the allied industries such as die casting, powdered metallurgy, synthetic rubber, etc., and plastic in its many forms, types of fabrication, and various resins. In many cases, it is difficult to determine which of the products will be most satisfactory and in some cases a combination may be the most satisfactory.

Because of the various uses for which standard motors are required, a long testing period is necessary and there is no complete assurance that a new material or part (plastic or other type) is satisfactory until it has operated in service for long periods. In many cases, an existing design has faults which are accepted as a matter of course due to long experience. Even if a plastic part will correct the faults of such a design, there will be serious complaints if even a minor difficulty develops because of the nature of plastics. The minor complaints are sometimes greatly exaggerated by users, customers, or by competition.

A pioneer in any new development in the electrical industry certainly treads on a bed of roses from which the thorns have not been removed.

Looking at an electric motor, you might wonder which parts are plastic. The writer has been asked why a motor designer should be interested in plastic.

Use of Plastics in Electric Motors

Table 1 lists the various uses of plastics in electric motors. It can be seen that many plastic items and materials are now used in electric motors and are taken for granted.

Speed Torque Curves in Repulsion Induction Motors

Figure 1 shows the relation of torque and speed in the repulsion induction motors. The repulsion torque is highest at start and decreases as speed increases. The induction torque is lowest at start and increases with speed. The chart shows that the two curves cross at approximately 200% full load torque. If we are to obtain the maximum performance from a motor design, it is apparent that a change over from repulsion to induction

PLASTICS IN ELECTRIC MOTORS

I Types of Application	II Motor Parts
1 Insulation	1 Insulation on conductors
	3 Terminal Boards
2 Structural	3 Switch Hubs
	4 Commutator insulation segments
	5 Commutator Hubs, etc.
3 Anti-Frictional	6 Thrust Washers
	7 Winding Wedges or slot sticks
4 Non-Corrosive	8 Slot cells
	9 End punchings
	10 Covering for coil ends
5 Surface Finish	11 Terminal busings, etc.
	12 Insulation varnishes
6 Wear Resistance	13 Paints and finishes

Electric Motors . . . .

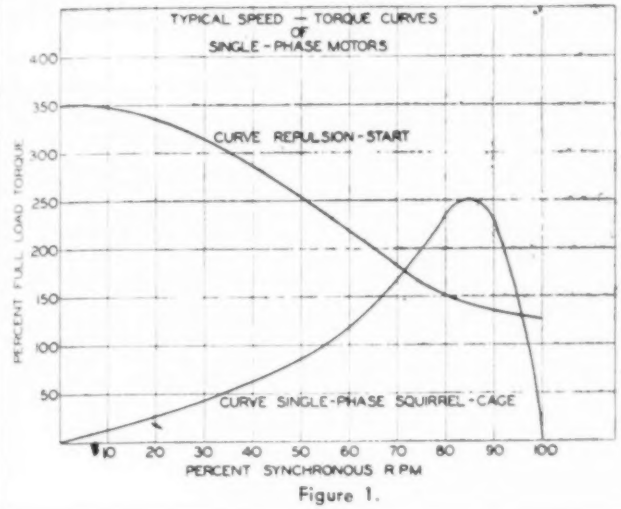


Figure 1.

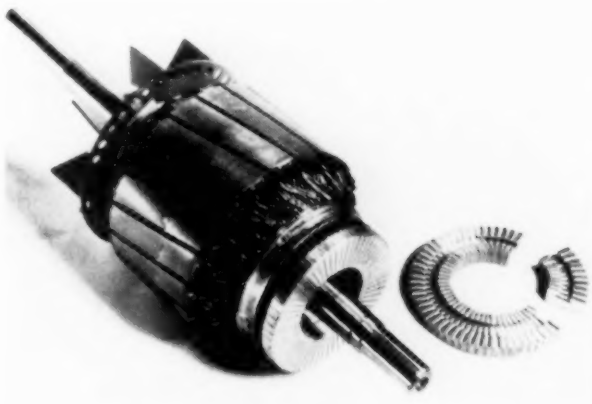


Figure 2. Armature and Commutator Segments.

operation should be made at definite speeds. This requires that the governor parts operate accurately and we will attempt to show how plastics have been applied in obtaining successful designs and the possibilities of future designs.

Armature and Commutator Segments

Figure 2 shows the armature and the segments of the commutator, copper and mica. This picture shows the dove tail slot into which the molding compound is forced and provides the means of holding the molded commutator together.

Development of Vertical Commutator

Figure 3 shows the development of a vertical commutator for repulsion induction motors.

The original design was purely mechanical. As shown in the drawing the segments are wedged into position and the commutator head provides a pressed fit over the segment rings which wedge the assembly into position. The segment wedge rings are held in position by means of screws. This design was in effect for many years and its use was continued until the advent of phenolic materials.

The original molded design was found generally to be satisfactory; however, when these commutators were abused through excessive temperatures or other adverse operating conditions, breakage sometimes occurred. Also in the original assembly, the "hammer action" used in the Winding Department when assembling the windings sometimes caused breakage.

Under normal operating conditions, this commutator was very satisfactory. However, this represented a case where the new development, the molded commutator, would not quite stand the abuse of the previous design. Many complaints were received from the service organizations because of breakage when repairs were made which did not occur with the previous mechanical design. Therefore, the reinforced design was developed. In this design a steel reinforcement adds the necessary strength. When this change was made another feature was added in which the three circuits in the commutator were isolated; namely, the main circuit to the winding, the winding and commutator segments to ground, and what we call the short circuiting path. This consists of insulating the brass ring "B" which causes a short circuit between the commutator segments and changes the electrical characteristics of the motor from repulsion type to induction type.

The insulation is indicated by insulation washers "A" and "C" and the molding compound "D." The insulation of this short-circuiting ring would have been difficult with the first two designs. With the reinforced design, it can be seen that the insulating of the short-circuit ring is a simple matter. The use of the insulated short-circuit path prevents stray currents, which develop under some extreme conditions, from passing through the lubrication film on the bearings and through arcing action causing etching of shaft and bearings.

The purpose of the short-circuit weights and the short-circuit ring is to short-circuit the commutator segments and change the characteristics of the motor from repulsion type to induction type. The desired circuit is, of course, between the adjacent commutator segments and the short-circuit weights.

In the original design of the repulsion induction motor, no difficulty was experienced due to stray currents. It can be seen that in the original designs no attempt was made to insulate the short-circuit weights from the hub of the commutator. As motor ratings increased in a given frame size with corresponding increase in current, the stray currents also increased. Unless the mechanism is insulated, the stray currents will pass from the commutator through short-circuit weights to the shaft. From the shaft, the stray currents will pass through the oil film into the bearing and then to the frame, thereby completing the circuit.

Under extreme conditions, an etching action occurs when these stray currents pass through the oil film. The use of the insulated short-circuit ring prevents stray currents from passing from the commutator and causing damage to the bearings.

The last view in figure 3 shows the future design. This design will be similar to the first molded design and is possible because of the developments in the plastic industry which supply molding compounds having greater strength. The use of this final design will require extensive changes in molding equipment. With this design, it will be possible to use injection molding which will require new equipment. This will require a considerable in-

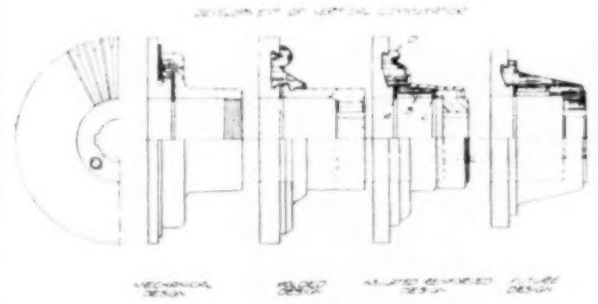


Figure 3

MOLD FOR COMMUTATOR

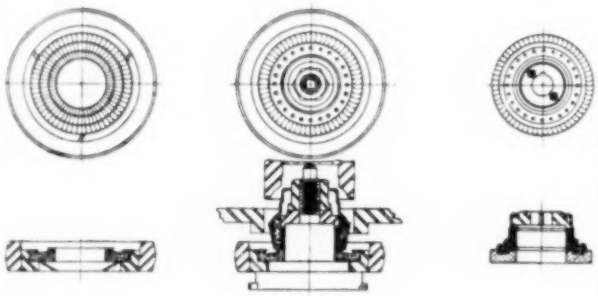


Figure 4

DEVELOPMENT OF SHORT-CIRCUITING MECHANISM

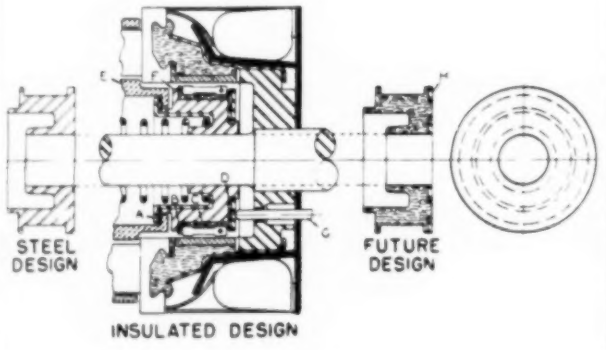


Figure 5

vestment but will be justified if satisfactory molding compound can be supplied and the design proves satisfactory in service. With injection molding, it appears that better curing can be obtained insuring maximum strength. Also, the time of the operating cycle can probably be reduced considerably. It is also apparent that there will be a saving due to eliminating the expensive parts; that is, hub, reinforcing ring, and insulation washers.

This commutator design is a good example of the role that plastics can assume in other industries in providing superior equipment at lower costs.

The molded commutator as shown in figure 3 represents a very unusual type of molding. The molding feature of this commutator is actually of a minor nature. The main function in the fabrication of this commutator is the assembly operation. It is apparent that the assembly of the copper and insulation segments, and the assembly of the various parts on the molding fixture, before the molding operation, requires considerably more time than the molding operation. It is also apparent that the cost of the molding compound is of a minor nature when compared to the cost of the copper segments, insulation segments and other parts.

Molding Operation, Vertical Commutator

The molding operation is shown on figure 4. The first view indicates the method of holding the copper and mica segments in position through the use of a clamp ring having a tapered bore. This clamp ring registers against split segments, which in turn hold the copper and mica segments in place.

This assembly is placed on a mandrel along with the other component parts of the commutator and the parts are clamped into position. This assembly is indicated on the second view.

The second view also indicates the molding operation in which the reinforcing ring is placed over the molding compound and the entire assembly placed into the mold.

The third view shows the completed commutator.

In order to obtain satisfactory commutators, the temperature, the time, and the pressure included in the cycle of operations must be closely controlled.

It can be seen that the major portion of the assembly is metal. In most molding operations, the percentage of inserts in the molded part is of a minor nature.

It was found that preheating of the molding material for this assembly was impossible. When preheated, the molding material became cured before the final shape could be obtained.

It would, of course, have been possible to heat the assembly to a temperature corresponding to a preheated slug of molding compound, but it is not possible for an operator to work under these temperature conditions.

The answer to the problem, therefore, was in excessive heating of the mold and removing the part before the molding material was over cured.

In this commutator we have also found it possible to use insulation segments made of plastic. Melamine impregnated linen fabric has given satisfactory service. The use of plastics for commutator insulation segments may be considered a future development. Besides the melamine we now have the polyesters which can be used with linen or glass, in either woven fiber or mat type.

The use of sheet plastic for insulation segments has provided a material which lends itself to high production methods. The sheet material is not subject to the splitting which occurs with mica. A machine has been developed

which punches the copper segments and automatically assembles the copper and insulation segments in a circle as shown in the first view of figure 2.

At the present time, this machine punches only the copper segments and the pre-punched insulation segments are automatically fed into the machine. With the sheet plastic, it will now be possible to also punch the insulation segments and automatically feed them into the assembly.

Another development is the mica mat which consists of small particles of mica fabricated into paper form. This can be bonded with silicone resin. There appear at the present time to be a number of developments regarding the use of plastics for commutator insulation segments.

Development of Sliding Part (Spring Barrel)

Figure 5 shows the development of what we know as a spring barrel. The original design is shown on the left hand side of the figure. This design was in effect for many years. When it became necessary in the development of the repulsion induction motor to prevent stray currents, the design in the center of the figure was developed. It will be seen that the small short-circuiting weights are insulated from the body of the spring barrel by means of phenolic tube "C" and phenolic washers "B" and "D." The use of this insulation prevents another path for stray currents which is through the spring barrel and shaft similar to the stray currents explained previously for the commutators.

The future design is shown at the right. This design will require the use of molding material having high strength and will also require the use of rather expensive molding equipment consisting of injection type mold with collapsible segments to provide the spool construction. The steel washer "H" is required to withstand the rubbing action of the commutator rods "G". Tests may prove that the molding compound has sufficient strength and the steel plate is unnecessary.

Capacitor Start Motors

Before discussing the parts of the capacitor start or split phase motor, we will show where these parts are used. Figure 6 shows the assembly of the capacitor start or split phase motor. In the capacitor start or split phase motor, two windings are required; the running winding and the starting winding. After the motor reaches the proper speed, it is necessary to disconnect the starting winding and to switch over to the running winding. In the capacitor start or split phase motors, it is also necessary that the starting winding be disconnected promptly in order to prevent damage to the starting winding or condenser due to excessive heat if the starting winding is not disconnected.

Speed Torque Curve

Figure 7 shows the relation of speed and torque in capacitor start motors. The chart indicates that the starting winding must be disconnected at definite speeds. This requires that the governor parts operate satisfactorily and we will attempt to show how plastics have been applied to the capacitor start or split phase motor and the possibilities for future designs.

Development of Sliding Part (Switch Hub)

Figure 8 shows the development of switch hub for split phase or capacitor start motor. In the original design a steel hub was used which was moved along the shaft by means of steel pins.

Because of noisy operation of this motor design, the switch mechanism was redesigned and a hub similar to the second view on the figure was provided. This hub

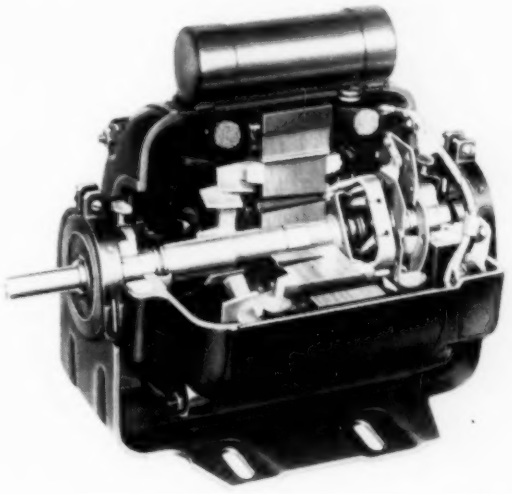


Figure 6. A capacitor start or split phase motor.

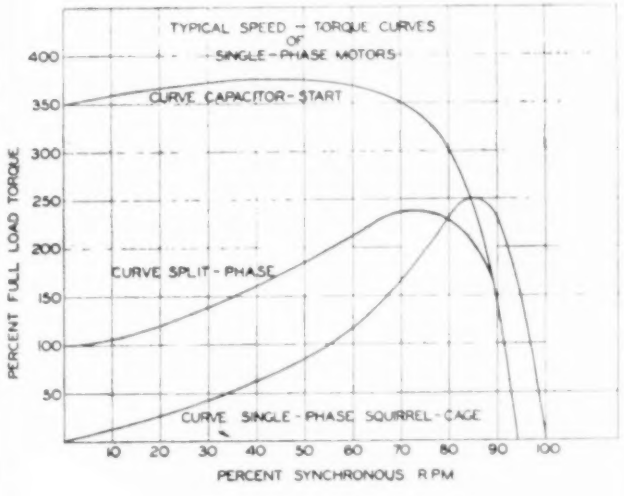


Figure 7. Speed torque curve.

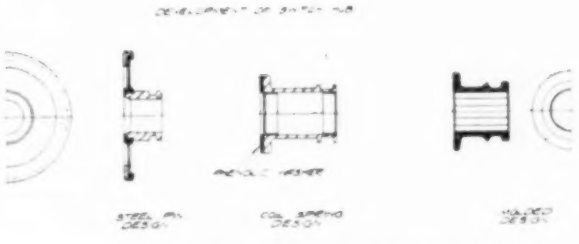


Figure 8. Development of switch hub.

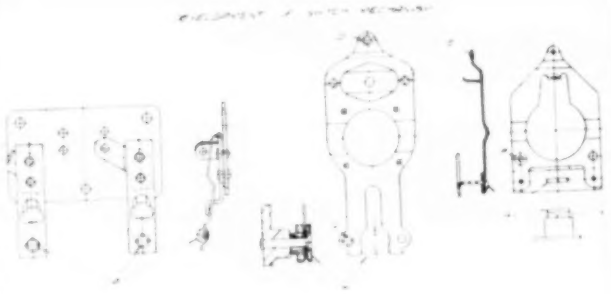


Figure 9. Development of switch mechanism.

Figure 10. Molded blower for electric motor.

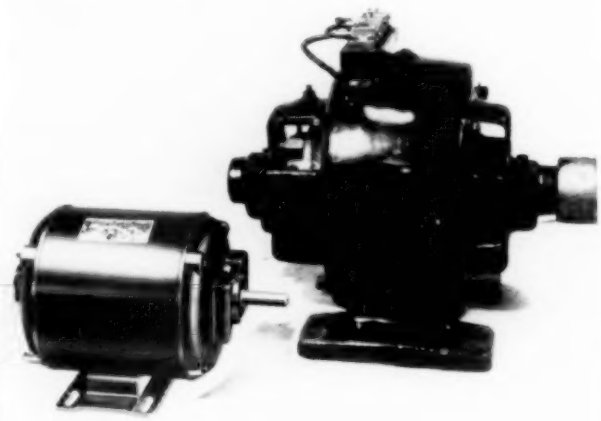


Figure 11. Electric motors of 1900—and today.

had a very close clearance on the shaft and a phenolic sheet washer provided the insulation between the switch and the hub.

Here again, noise occasionally occurred due to clearance between the switch hub and the shaft. The hub is moved along the shaft by means of extension springs which also control the speed at which the governor weights operate. It was found that these coil springs became worn because of contact with the steel hub.

Referring again to figure 8, the molded hub of shorter length was, therefore, developed along with other changes which were made when the motor was shortened.

With this hub, there was no noisy operation and no excessive wear of the coil springs.

It will be noticed that with the molded construction the flats were possible in the bore at much less cost than could have been provided in a steel hub. The flats in the bore make it possible to maintain a small clearance with the shaft with very small contact, which is necessary in order to prevent friction which might affect the operation of the switching mechanism.

One of the important requirements of this hub is the heat treatment. It is necessary that the parts be baked for a long period of time, approximately 24 hours, in order to prevent distortion after parts are placed in service.

Development of Hinge Part (Switch Mechanism)

Figure 9 shows the development of the switching mechanism on a split phase or capacitor start motor. This development shows a construction using the particular properties of plastics; that is, rigidity, maintaining shape, anti-frictional properties, and not subject to corrosion.

The action of a switch in a split phase or capacitor start motor is controlled by springs of various types. The load carrying capacity of the motor requires that the governor weights operate the switch contacts at definite speeds. The problem is to provide a construction which has the minimum in friction and will not be affected by conditions in service. It is apparent that if corrosion, warping of parts, etc., would cause sluggish action of the switch that the operating characteristics of the motor would be affected.

The first view shows a construction in which a flexible bronze member carries the contacts. A revolving member causes connection between the two contacts as indicated at "A". The flexible phosphorous bronze member is insulated from the endbell of the motor. It is apparent that this design was more sluggish and had greater friction than the later floating design.

The second view shows a design using a molded collar as the supporting means as indicated at "B". One lead is attached to this member at "C" and contact is made through a silver contact "D" at the other end. This contact is actuated by the hub on the shaft. This design removes some of the objections to the original design but was still subject to some sluggish action.

The third view shows the final design where a light floating member provides the minimum of friction. One lead is attached to this member at "F" and contact is made through a silver contact "E" at the other end. It will be noted that the hinge action is provided by very light contact between the punched part and the phenolic sheet as indicated at "G". No material other than plastic could provide the necessary rigidity and freedom of distortion, combined with satisfactory frictional properties. The switch is mounted on the endbell and is actuated by governor weights and hub mounted on the shaft.

(Please turn to Page 53)

Szantay of Santay

M. A. Self

Friday mornings at 10:30, a curious meeting takes place at the Santay Corporation in Chicago. Ten stalwart men, all key executives of the company, come in and take their places around the table. But the meeting does not begin until a youngish, brown-haired and brown-eyed woman only five feet tall, comes in and takes her place at the head of the table. "Vi," as she is known to everyone from the porter to the president of the company, is Miss Violet Szantay, vice president of Santay Corporation, mentor of some 700 employees, chairman of the company's policy committee, overseer of the company's $7 million annual production, and most important of all, the only female member of the Chicago chapter of the SPE.

Keen, affable and with a smile which reverberates around a room, Miss Szantay was born in the plastics industry and has herself gone through every phase of the business. Her father Daniel Szantay, started the company way back in 1919. Her brother, Elmer Szantay, started the Sandee Manufacturing Company, which is an extruding company, in 1940, and is still going strong. Despite these hereditary influences, Miss Szantay still had to prove her ability before she was made vice president of Santay in 1950.

Her first preoccupation with frivolity, as she recalls it, was when she was a student at Von Stuben High School in Chicago, and her father took her to a formal dance—the tool and die makers ball, held at the Midwest Athletic Club. She was greatly impressed, she said, with the "wizards" who make the tools and dies from which everything else was produced. Her father, Daniel Szantay, had originally been a tool and die maker and impressed upon her that without tool and die makers the country would quickly revert to the Indians, a belief which she still shares. However, in those days, her main concern was how to edge her way into the young plastics industry—a field which regarded the presence of a lady executive as so strange as to appear fabulous.

After graduating from the University of Chicago in 1938, she went to work for several companies in various capacities, then started with her brother Elmer at the Sandee Manufacturing Company. She was in charge of all the office routine—and

Violet Szantay

in a pinch would rush out and shove her 100-lb., five-foot frame under some huge shipment being loaded onto a truck. This highly instructive panorama not only gave her a bird's-eye view of the industry, but also a worm's-eye view.

In 1946, the Santay Corporation wanted the benefit of Miss Szantay's abilities; so they elected her to the Board of Directors. Later, her father prevailed upon her to come to Santay Corporation as his assistant, to coordinate all the departments. Her incessant interest in the plastics business soon persuaded the other executives that she was avidly interested in plastics and the Santay Corporation.

As Miss Szantay explained it, there was no reason why Santay Corporation could not do things other plastics manufacturers were unable to accomplish. The Santay Corporation had everything under one roof—it made its own tools, molded its products, had its own assembly and finishing facilities. Moreover, it could make plastic and metal stampings and then put them both together efficiently and quickly. Since one of the major virtues of every plastic company is flexibility, Miss Szantay pushed, pulled, cajoled and persuaded every customer of the company that quick change and rapid production were the secret competitive weapons of Santay. Moreover, the ability to combine plastics and metals was very rare in the industry, and Miss Szantay made the most of them. Together with this ability was know-how (the Santay Corporation has been in business over 33 years). This accounts for the fact that every car radio in the country, and practically every home radio and television set has some part in it or on it which came from Santay.

Miss Szantay feels that Santay Corporation is almost as much responsible for the growing television industry as Milton Berle—a belief which has a disconcerting but inescapable plausibility.

Even the engineers around the company, accustomed as technical men are to being let alone by the sales and policy people, find that Miss Szantay is not a stranger in her field. Detective work discloses that she usually reads chemical and engineering journals while eating lunch in the plant, and anyone who has a new or red-hot idea, will find her an avid listener.

Today at least 75 per cent of Santay's $7 million production is molded and finished (sprayed, hot stamped, assembled, etc.) at the plant and shipped. Miss Szantay has a passion to build the Santay reputation so that the company is the boast and pride of everyone of Santay's 700 employees and is known from one end of the country to the other as the top quality producer at the best price.

Much of this philosophy accounts for the Santay emphasis on good molds. As readers of the SPE Journal know, good molds require the least amount of maintenance, give strong plastic pieces with excellent appearance and simplify finishing problems. The emphasis upon molds at Santay accounts for the fact that the inspection of its products, discloses virtually no rejects. The company now produces pieces for the following industries: radio and television, refrigeration, stoves, automotives, building suppliers, metals, electrical, electronics, air conditioning, candy vending machines and war work in plastics and metals.

Despite the complexity of company operations, Miss Szantay manages to keep an eye on everything—including even the housekeeping in the plant.

One of her first moves when she became vice president, was to order the plant currycombed—i.e., painted and all the floors cleaned. The men on her policy committee now smilingly admit that the changed appearance has radiated everywhere and has helped employee morale. They are now waiting for the time when she will put curtains in the molding room—a project which has long been gestating in her mind. And when this does happen, if one may judge by past experience, it will probably be after Miss Szantay has given the matter long and careful thought and then figured out how such curtains would either increase the flexibility of company operations or bring down costs.

Plastics Know-How—Part II

Plastics Literature In

James Kanegis

Irvin Wolock

James Kanegis

Office of Technical Services
Department of Commerce

and

Irvin Wolock

National Bureau of Standards
Department of Commerce

This is the second in a series of articles designed to describe the sources of plastics information and where it can be found.

THE DISCUSSION of technical literature on plastics in government reports is a timely one because such reports are rapidly multiplying into a larger and larger segment of the total technical literature each year. Formerly a literature search could be considered fairly complete when existing non-government sources were carefully checked. With the advent of World War II, however, the situation changed radically. The government initiated expenditures of large sums of money for scientific research. It developed and enlarged a contract type of research and development operation which has been continued since the war under the direct administration of various government agencies concerned with national defense. This rapid expansion of research and the corollary reports have greatly affected the dissemination of technical information and have brought into prominence the heretofore insignificant intragovernmental distribution channel (1).

Many reports issued by technologists and scientists either in the government or working on government contracts are released through the recognized scientific and technical journals. These reports can be located through the usual media such as Chemical Abstracts. Many government reports, however, which issue from such personnel may not be found listed in the above abstracts since they do not appear in the published literature.

There are many reasons for this situation. First, a large percentage of government reports are prepared to supply specific information and are not meant for publication. In the form prepared, they would not be considered as meeting the standards of the scientific journals. This type of report can be justified, however, on the grounds that it produces a maximum amount of information with a minimum amount of time and money.

For example, a large number of research and development reports are written by personnel of the Atomic Energy Project to record procedures, data, and results of immediate interest to other scientists, engineers, and technologists throughout the Project. These reports are reproduced by the contractor or the Technical Information Service of the Atomic Energy Commission for immediate distribution within the Atomic Energy Project. The journals often are not interested in such papers in their original form or may not be able to publish them promptly (2). These reports are typical of a large group of government reports that do not appear in the journals and that make the searching of government reports a slightly difficult and somewhat unique process.

Often, reports submitted to government agencies by industrial companies or government laboratories contain information of a proprietary nature. The circulation of these reports is closely controlled until such information is deleted. Typical of these are reports of evaluation tests conducted for government agencies which frequently contain proprietary information and are not published or generally circulated until suitably revised. Reports of this sort are unfortunately, often never revised for release to the public.

Possibly the main reason that many government reports do not appear in the standard periodicals is military security restrictions. Much of the work done under government contract is of a classified nature and, as such, the circulation of the resulting reports must be closely controlled. These reports are not available to most government workers as well as to the general public until declassified.

Consideration must also be given to the fact that there is not enough space available in the regular journals for the publication of all government reports. If all government reports were prepared for and submitted for publication in the journals presently available, the results would be catastrophic. As it is, most of these journals have built up a backlog of the material presently channeled to them.

Thus one finds that the search for pertinent literature among government reports is a process which is largely independent of a search conducted among non-government

Presented at the A.C.S. Symposium on the Literature of Synthetic Resins and Plastics, September 1952, and here printed by special arrangement with the American Chemical Society.

Government Reports . . . .

sources. It is the purpose of this report to indicate means of locating pertinent government reports, particularly those concerned with plastics, largely by indicating most of the more important agencies issuing such reports. It must be stressed, as will be indicated later, that no attempt was made to list every government agency which has issued any reports concerning plastics, nor to list every publication of these agencies which are mentioned. This report should be considered rather as an attempt to lend direction to the search for these particular government reports, with explicit information furnished on many of the more important agencies.

It should be pointed out that publication policies in government agencies will be found to vary from time to time, as the functions and appropriations of these agencies change. Also, many agencies have a very fluid publication policy which might make a literature search more difficult. Such a policy is followed to allow the agency to direct certain publications to the most interested audience and to allow the scientist more freedom of publication, even to the extent of indicating whether the report is ready for publication and if so, in which journal. Such freedom of publication serves to attract more competent men into the government service.

There are several publications which will be of general assistance in searching for technical literature in government reports. Among them is an article by Jerome K. Wilcox (3), which lists guides and aids, issued during the period 1945-1948 for the use of public documents. N. T. Ball and C. R. Flagg have presented an article (4) which deals with ways of finding and using government publications that may be particularly useful to chemists. Detailed information is given on technical publications of those government agencies of most interest to the chemist.

The technical information activities of the Department of Defense are described in another publication (5), with supplementary information on other government agencies.

One of the best ways of checking on reports by federal agencies is to know of the individual government agencies. The best and most recent listing of such agencies will be found in an eight page appendix to a report (6), issued by the National Research Council in March, 1952, which lists the research and development facilities of the U. S. Government, giving name and location of each laboratory under the headings of the various government departments.

Another publication which will familiarize the individual with the various government departments is the annual **United States Government Organization Manual** (7) which contains a description of all of the government agencies. An appendix lists representative publications available from the various government establishments.

Government Printing Office

It is probably quite natural to begin a discussion of particular government agencies issuing reports with the Government Printing Office. The **Monthly Catalog** (8), issued by the Superintendent of Documents, is the most comprehensive periodical issued listing publications of the various government agencies. The catalog contains both technical and nontechnical publications issued by the various departments and agencies of the U. S. Government. It is indexed annually.

A list of **Selected U. S. Government Publications** (9) is issued semimonthly, arranged alphabetically by subjects. Probably of most interest to plastics technologists is a list of **Publications Relating to Plastics** (10) issued in February 1951. This is a mimeographed list, containing titles and Government Printing Office catalog numbers only, of reports from many federal agencies. This listing is not comprehensive, however, and because of the date of issuance, must be supplemented by the **Monthly Catalog** for more recent reports.

Office of Technical Services

The Office of Technical Services (OTS), of the Department of Commerce, was established after World War II and is responsible for aiding in the collection and dissemination of technical reports of benefit to American science and industry. These reports are received from the civil and military agencies of the United States Government and from cooperating foreign governments. Many of the reports cover information captured in enemy countries. Thus the vast store of reports on German developments in plastics prepared after the last war was made available through OTS. However, of present significance is the fact that all declassified Department of Defense reports as well as those of the Office of Scientific Research and Development (OSRD) are distributed through OTS.

OTS maintains a voluminous card file of all of the abovementioned classes of reports in Washington. Its listings of reports of federal origin in the plastics field is probably the most extensive to be found. There are over 2000 card listings under plastics, not counting those listed under specific plastics or other subject heads. No attempt has ever been made to furnish a full bibliographic listing of these reports and it is extremely doubtful that such will be done. However, a selected **Bibliography of Reports on Plastics** (11) has been prepared, containing some 400 such reports but mostly covering the German technology. That agency is planning a more extensive list to include declassified reports of federal origin.

OTS has two regular publications. The **Bibliography of Technical Reports** (12) is issued monthly, listing most of the pertinent reports received and abstracting most of those listed. The **Technical Reports Newsletter** (13), also a monthly publication, is a digest of outstanding technical reports available from federal and other nonconfidential sources. Special emphasis is placed on items of interest to smaller business firms.

National Bureau of Standards

The results of work conducted at the National Bureau of Standards (NBS), Department of Commerce, are made available through publication either in the Bureau's own series of publications or in the technical journals. The Bureau publishes a monthly **Journal of Research** (14) which presents complete papers reporting technical investigations. There is also a monthly **Technical News Bulletin** (15) which carries summary reports on some of the completed projects with emphasis on the results of research. Preliminary reports on work in progress are

also presented along with a listing of all Bureau publications during the preceding month. There are various Circulars and Miscellaneous Publications issued from time to time. A list (16) of the titles of these publications and of reprints from the Journal of the Research through December 31, 1951, is available.

Circulars of greatest interest to those concerned with plastics are **Plastics Research and Technology at the National Bureau of Standards** (17) issued in June, 1950, which includes a bibliography of NBS plastics reports; and the **Bibliography of Recent Research in the Field of High Polymers** (18), issued September, 1950. A supplement to the former circular is now available to cover the period through August, 1952.

National Advisory Committee for Aeronautics

The National Advisory Committee for Aeronautics (NACA)is a valuable source of information concerning plastics materials used in aircraft, such as transparent plastics, adhesives, and laminates of various types. Many reports on these materials will be found in two comprehensive indexes (19, 20) of NACA technical publications. The reports are listed under subject headings, one of which is "Plastics." To supplement the above, **NACA Research Abstracts** (21) is issued biweekly, listing reports on projects sponsored by the NACA, along with abstracts of the contents. All NACA reports are available at the NACA library in Washington, along with numerous other reports regarding aircraft and aircraft materials from many sources.

Department of Agriculture

Work is sponsored by the Department of Agriculture on the use of agricultural products in making plastics, largely by the Bureau of Agricultural and Industrial Chemistry. In addition, the Forest Products Laboratory has conducted extensive work on the uses of resins in wood and paper adhesives, impregnates, and laminates.

The Department of Agriculture issues a **Monthly List of Publications** (22) giving the author, title, and issuing bureau of each printed publication. In addition, a list (23) was issued July 1951, giving the titles of all publications issued by the Department of Agriculture itself and still in print, but not those issued by all of its constituent bureaus. There are few reports concerning plastics in this catalog. The Bureau of Agricultural and Industrial Chemistry, however, has a listing of all of its processed publications (24), issued January 1952. This listing is of great interest to those concerned with plastics and is revised periodically.

The Forest Products Laboratory also has a semiannual **List of Publications** (25) and a **List of Publications on Chemistry of Wood and Derived Products** (26), which contains items pertaining to plastics.

Atomic Energy Commission

As a corollary to its main lines of endeavor, the Atomic Energy Commission (AEC) has produced a significant amount of information of interest to those concerned with plastics. Much of this has been declassified and is available to the general public through the usual information activities of the AEC.

A semimonthly journal, **Nuclear Science Abstracts** (27), is issued by the AEC. It contains abstracts and an index of all current nonclassified research and development reports disseminated by the AEC and its contractors, as well as pertinent nonclassified reports issued by other government agencies or appearing in foreign and domestic journals.

Several hundred declassified AEC reports appear in the National Nuclear Energy Series (NNES), which is a record and summary of the research carried on by the Manhattan District and the AEC. These volumes are being published by McGraw-Hill and their contents are listed in **Nuclear Science Abstracts.** Of special interest may be the volume **Preparation, Properties, and Technology of Fluorine and Organic Fluoro Compounds** (28). Much of the development work on fluorocarbon polymers was done by the Manhattan District during the last war, and AEC-sponsored publications are a valuable source of information on these materials.

Over 1500 AEC reports have been published in the usual scientific and technical journals and are also listed in **Nuclear Science Abstracts.** However, over 1600 reports have not been published in journals or listed in the NNES but are for sale by OTS, from which price lists may be requested. These reports are also listed in the monthly catalog of the Government Printing Office. Nearly all the nonclassified AEC research and development reports which are not published in journals or in the NNES are supplied to 40 depository libraries located throughout the country and are thus readily available to literature searchers. A list of these libraries is contained in a booklet **Availability of USAEC Research and Development Reports** (2).

Department of Defense

It has been estimated that the research and development programs of the Department of Defense produce over 100,000 scientific and technical reports each year. The dissemination of this information has been handled by two separate agencies, the Central Air Documents Office (CADO) at Dayton, Ohio, and the Technical Information Division (TID) of the Library of Congress, formerly called the Navy Research Section. In May 1951, however, the Armed Services Technical Information Agency (ASTIA) was established to provide an integrated program of scientific and technical report services for the Department of Defense and its contractors by merging the two existing services. The process of integration is now taking place. It is the responsibility of ASTIA to collect, catalog, and abstract technical reports issued by various bureaus, offices, and contractors of the Department of Defense and any other reports in fields of interest to the National Defense. In addition to supplying abstracts of these reports to qualified agencies and contractors, a report lending service and reference and bibliographic service are conducted. As of the present, ASTIA has taken over the functions of CADO and is now in the process of taking over the activities of TID.

ASTIA's main channel for distributing abstracts of reports it receives is through its ATI catalog cards. It also issues a monthly publication, the **Technical Data Digest,** which is now Restricted, and which contains original articles, extracts of papers of interest in various fields of research, and abstracts of current magazine articles of a technical nature.

The TID issues a **Technical Information Pilot** (TIP) periodically, containing abstracts of all reports received; it is issued in four security classifications including Unclassified. There is an annual index omitting the abstracts of each report. TIP catalog cards are also available for convenience in cataloging the reports; these cards contain abstracts identical with those appearing in TIP.

In addition to the above functions, the Technical Information Division is preparing a series of book catalogs covering the approximately 30,000 technical reports issued during World War II under the auspices of the Office of

Scientific Research and Development (OSRD). The catalogs are issued by subject divisions, there being a total of 22, and distribution is handled by OTS. From the point of view of the plastics technologist, the matter of OSRD reports is complicated by the fact that none of the divisions were specifically concerned with plastics. Nevertheless, many reports were issued about plastics and one should turn to the OTS to locate these reports. It should be kept in mind that the OSRD functioned from 1940 to 1946 only, so that work of a more recent nature should not be looked for in these reports.

As noted previously, when Department of Defense reports are declassified and made available to the general public distribution is handled by OTS through its normal channels. The majority of literature searchers will deal with OTS and the statements previously made regarding OTS should guide the individual in finding and obtaining these reports.

The above is a very brief summary of the activities of ASTIA, CADO, and TID. Further details may be obtained in several recent publications (4, 5, 29, 30).

Bureau of Mines

The Bureau of Mines, Department of the Interior, through its interest in mine safety and allied fields, has issued two recent reports on **Inflammability and Explosibility of Powders Used in the Plastics Industry** (31) and **Toxicity and Flame-Resistance of Thermosetting Plastics** (32). This Bureau lists all of its publications in a main index covering the period 1910-1948 (33), with later reports covered in annual supplements (34).

Public Health Service

As previously indicated, a familiarity with the functions of government agencies is extremely helpful in making a literature search of government reports. It makes possible interrelating an agency and its potential reports. Thus one finds that the Public Health Service has published several articles on industrial hazards in the plastics industry (35, 36, 37), with emphasis on Dermatitis. Most of these articles have appeared in the monthly publication, now known as **Occupational Health** (38), of the Division of Occupational Health.

Prevention of Deterioration Center

The Prevention of Deterioration Center, sponsored by the Department of Defense, issues a monthly publication **Prevention of Deterioration Abstracts** (39). It is the most comprehensive in the field and covers material from other sources in addition to government documents. One of the sections is designated as "Plastics, Resins, Rubber, and Waxes." A fairly liberal interpretation is placed on the term "deterioration" so that coverage is somewhat more than one might anticipate. The Center also has a monthly **Advance List** (40) which covers in bibliographic form only all reports received by the Center. About one-third to one-half of these are later included in the Abstracts.

The Abstracts and Advance List are available free of charge to those agencies and institutions conducting deterioration studies for the Department of Defense and so certified. They are available to the general public on a cost subscription basis.

This Center is preparing a comprehensive book on the prevention of deterioration of materials, to be published by a commercial publisher early in 1953.

Department of Commerce

The library of the Department of Commerce has just issued a comprehensive index of publications of the Department of Commerce and all of its agencies (41). The index covers reports issued through October, 1950 and it is planned to issue regular supplements in the future. This publication contains a subject index with "Plastics" as one of the sub-headings.

The library also issues a weekly **Business Service Check List** (42) which lists some of the recent and more useful Commerce publications, including those of the National Bureau of Standards and the Office of Technical Services.

In 1949 a survey of basic information sources on plastics (43) was prepared by the office then known as the Office of Domestic Commerce. This survey lists publications of various agencies of the Department of Commerce as well as other government departments. Textbooks and periodicals concerned with plastics are also listed. Some of the information is dated and no longer correct but the general information is still of value.

Another publication of unusual interest is the **Chemical Statistics Directory, No. 2** (44). This provides an index to the chemical statistics available from government sources for the years 1946-1947. This report has not been revised as originally planned; nevertheless, the sources listed are still mainly correct.

Among the Department of Commerce periodicals is a **Foreign Commerce Weekly** (45) issued by their Office of International Trade, containing news items and articles on various commodities of interest to the foreign trader, including plastics and resins. As of July, 1952 the format on this publication is now more on special articles and a definite attempt is made to obtain a more current discussion of pertinent information. A somewhat related publication by the same office is the **Foreign Commerce Yearbook** (64). These publications give appreciable statistical data on plastics and resins.

An excellent paper on sources of government statistics on chemicals (46) was presented recently at an ACS convention by Miss Margaret Donnelly, formerly of the National Production Authority of the Department of Commerce. Reprints of this paper are available from NPA.

Other agencies of the Department of Commerce not discussed so far are the Bureau of the Census and the Patent Office. They are covered briefly below.

Bureau of the Census

Some of the data published by the Bureau of the Census, Department of Commerce, will be of interest to those concerned with statistics of the plastics industry. In the **Census of Manufactures—1947** there is a section on **Industrial Organic Chemicals** (47) and one on **Plastics Products; Miscellaneous Manufactures** (48). Each section is available as a separate publication. The former includes statistics on the plastics materials industry while the latter concerns the plastics products industry. Presented in each section are data on employment, pay rolls, value added by manufacture, value of shipments, cost of raw materials, expenditures for plants and equipment, and other categories. The next complete census of manufactures will be made in 1954 to cover 1953. A general survey made for 1950 is available (49), but the information is not nearly as comprehensive as that in the **Census of Manufactures.**

The Bureau of the Census has also published a statistical history of the growth of plastics through 1939 (50) based on data from the **Census of Manufactures.**

U. S. Patent Office

Patents relating to plastics can, of course, be found through the usual search routines, something which is outside the limited scope of this paper. Specific patents may be ordered from the U. S. Patent Office, Department of

Commerce, or may be examined in the Patent Office in Washington or in a number of libraries throughout the country. At a nominal charge, the Patent Office will furnish a full list of patents for any class and subclass desired. This facilitates patent study in those cities which have bound volumes of U. S. patents.

One cannot always be sure which agency in the government will turn out a report of more than usual interest. Thus one might not expect the Patent Office to have any reports of unusual interest to the public. One finds, however, that the only publication listed in the Government Printing Office's "Government Best Sellers" which has plastics as its main theme is one put out in 1949 by the Patent Office (51). This report lists representative patents available for plastic products and processes from three types of patents: (1) patents available for licensing or sale, (2) government-owned patents, and (3) dedicated patents. Instructions for locating other such patents are given. Unfortunately for really complete coverage, it would have to be brought up-to-date.

In discusing patents, reference should be made to the fact that the office of Alien Property of the Department of Justice has made available patents formerly owned by our former enemies and seized by the government during the war. Thousands of ideas for new materials, new processes, and new products are disclosed in these patents which are put into use under a liberal licensing program administered by the Office of Alien Property. These patents have been carefully abstracted, classified, and indexed. A list of all of the subjects under which the patents have been classified is available (52), from which the complete set of abstracts for any subject may be ordered. One group of patents is listed under the heading of "Plastics; synthetic resins." Individual patents may then be selected from the abstracts and ordered from the Commissioner of Patents.

U. S. Tariff Commission

Data isued by the U. S. Tariff Commission are of particular interest to plastics processors and consumers because that agency is primarily responsible for statistics on organic chemicals. The yearly issue of **United States Production and Sales of Synthetic Organic Chemicals** (53) is an excellent guide to actual production and sales of plastics and resin materials, as well as plasticizers and the synthetic rubber polymers and copolymers with synthetic resins. The complete report for 1951 will be available in the fall of 1952. The section on plastics may now be obtained separately, however (54). In compiling the data for the above annual report, the Tariff Commission depends somewhat on its monthly **Report on Production and Sales of Synthetic Plastics and Resin Materials** (55). The production and sales figures in this publication are listed by types of plastics, using a grouping different from that employed in the annual report.

Many agency reports originate with requests for such reports from Congressional Committees. An excellent example of this is the report on **Plastics Products** (56) issued by the Tariff Commission in 1948. This is part of the "War Changes in Industry" series prepared by the Tariff Commission when requested by Congress to investigate the principle domestic industries affected favorably or unfavorably by the war and to report regarding their prewar status, the changes and developments that occurred during the war, and as far as possible, their probable postwar status in foreign trade and international competition.

Department of Labor

Typical publications issued by The Bureau of Labor Statistics of the Department of Labor are two monthly bulletins, **Employment and Payrolls** (57) and **Hours and Earnings** (58), each containing a subheading of "Plastics Materials." These will be of interest to a limited group. The annual supplements are contained in the respective April issues.

In 1948, this Bureau published a report on **Employment Outlook in the Plastics Products Industry** (59).

Specifications

A detailed discussion of specification is also outside the scope of this paper. Briefly, there are approximately 15,000 to 20,000 specifications available, in two main categories: Federal and Military. An **Index to Federal Specifications and Standards** (60) is issued annually. The **Index to Military Specifications** is issued semiannually and is published in four volumes: I Munitions Board; II Army; III Navy; and IV Air Force (61-63).

Volume I, Munitions Board, was discontinued as of October 1952 in the interest of economy and to avoid unnecessary duplication.

Summary

It becomes obvious that the publication activities of the various agencies of the United States Government are very diversified and in addition are constantly changing. Whereas years ago, any attempt to give a reasonably comprehensive coverage of federal publications was apt to remain accurate for some time, it is not true at the present time. In many instances, with the many functions now being fulfilled by government agencies, there has been an increasing tendency to turn to a limited type of report as a medium for attaining their objectives, at least in part. While no great attempt is being made to publicize them they are sent to inquirers whenever the agency finds the reports suitable and in such cases will often supplement this material by special letter. Even "non-technical" agencies such as the Department of State occassionally prepare reports of technical interest. Thus one finds a Foreign Service Dispatch from Sweden discussing a method of restoring optical clarity to old glass by the application of a plastic film.

It is difficult if not impossible to track down all government reports in a reasonable time for reasons such as these. Some attempts are being made to concentrate these activities into one or more agencies but any discussion of such possibilities at this time would be premature. The judicious selection of federal agencies based upon their primary and secondary interests is a necessary supplement to any search activities. This can best be done by developing some familiarity with the activities of the various agencies in government.

In substance, if one checks over the indexes of the Government Printing Office **Monthly Catalog**, and certain of the published government agency indexes such as those of the Department of Agriculture and the National Bureau of Standards, then checks the Office of Technical Services on its publications and coverages of its 150,000 publications and solicits their aid in locating government reports on a given subject, it is possible to obtain fairly satisfactory coverage of such reports. This assumes, of course, that an agency in which there is a known supply of information such as statistical figures from the Bureau of Census and the U. S. Tariff Commission, has already been contacted. For a more meticulous search thereafter it would be necessary to take a more time consuming approach of contacting other agencies in government in which there exists even a slight suspicion that there is material of interest. This activity naturally follows the

(Please turn to Page 54)

Thirteen Leading Plastics Firms Unite to Promote Wider Use Of Large Moldings

Last November plans were made to step up the use of large thermosetting plastics moldings in the radio, television, home appliance, furniture, and office machine fields. Seven leading materials producers and six molders with more than 10-million dollars in molding capacity formed the Committee on Large Plastics Moldings, directing an unusual and extensive, hard-hitting campaign to acquaint the public, manufacturers, industrial designers, and interior decorators with the many advantages of large well-engineered thermosetting plastics moldings.

This Committee work is being financed jointly by American Cyanamid, Bakelite, Borden, Durez, Monsanto, Plaskon, and Plastics Engineering, American Insulator, Chicago Molded Products, General American Transportation, Molded Products, Prolon, and Richardson Company. The G. M. Basford Company has been retained by the Committee to handle this public relations campaign.

It is their plan to acquaint the public with new developments in large plastic products and their advantages; to stimulate designers to develop functional designs that will capitalize on the strength and beauty of plastics; and to help manufacturers in fields such as the home appliance, furniture, kitchen equipment and the like to understand the economics of the use of large, high-strength unit moldings for their consumer products. This campaign, we believe, will be of tremendous benefit to business generally; it will have far reaching effects in the chemical, consumer manufacturing, machinery, tool and die, and plastics moldings fields.

A press conference in New York announced the formation of the Committee and its objectives to press representatives from New York newspapers, industrial and trade magazines. In addition, a press release announcing the formation of the Committee and its objectives was directed at all interested national and regional publications in consumer, merchandising and industrial fields.

Important factors brought out at the press conference are these six advantages of thermosetting plastics materials in large moldings:

1. Design of moldings can be functional.
2. Won't show scratches, color goes all the way through the material; or, it can be painted.
3. Plastics housings are strong yet light in weight; they have the appearance of solidity.
4. The finish resists rust, burns, alcohol, and other staining liquids.
5. Good acoustical qualities.
6. Because of the five foregoing reasons, plastics housings are eminently suitable for use anywhere in the home. They will blend with modern home decor—they are "good furniture."

This last point is one that is gaining popularity fast. Plastics housings, once exiled to kitchen appliances and furnishings, now can be compatible with interiors or other rooms in the home.

An important factor brought out at the meeting is the $10 million worth of capital equipment available in the molding phase of the industry alone. The companies are in a strong financial position and are ready to increase facilities. Several have active plans to do so under way at present. So far as users are concerned, one appliance manufacturer at present has $250,000 worth of dies in current production with a leading molder.

Another phase of the expanded program announced by members of the Committee on Large Plastics Moldings will be symposiums with designers as well as furniture and appliance manufacturers and other key groups. These can foster the exchange of know-how and thus increase the pace of product improvement.

The Committee also intends to supply users of large plastics moldings with promotional material on how to care for plastics for use in manufacturers' point-of-sale literature and displays.

What Has Been Done

The story on the formation of the Committee has been published nationally. It has been used, for example, by such publications as NEW YORK TIMES, WALL STREET JOURNAL, BUFFALO EVENING NEWS, KANSAS CITY STAR, DETROIT FREE PRESS, and by such business and technical magazines as RETAILING DAILY, MATERIALS & METHODS, IRON AGE, BUSINESS WEEK, TIDE, and FINANCIAL WORLD.

Feature articles prepared for the Committee already have appeared in ELECTRICAL MERCHANDISING, BUSINESS WEEK, QUICK. The first story told the appliance dealer that he would be seeing more and more products using large thermosetting moldings in manufacturers' new appliance lines, gave him the sales features of these products to help him merchandise them. It also subtly pointed out that plastics have become "good furniture."

In addition to articles, the Committee's program includes joint meetings with present and prospective users of large moldings. The first of these meetings has been scheduled for April 15th at the Engineers' Club in New York. The Committee will sponsor it jointly with the Society of Industrial Designers. The panel discussions at this meeting will be devoted to such subjects as new materials; new moldings techniques; suggestions to the designer for making the most of plastics' potentialities for clean, function design; explanations of the need for closer cooperation between all groups for greater interchange of information.

Two panel discussion sessions will be conducted at this joint meeting.

Representatives from manufacturers of these products will be invited to attend the sessions—some to participate on the panels, others to listen to the proceedings and then participate with comments from the floor.

A subsequent conference jointly sponsored by the Committee and the Society of Industrial Designers is planned for Chicago in the late spring. The program essentially will be the same.

Other projects under active consideration by the Committee, and on which work now is being done, include informative labelling for large moldings—to present accurate, concise information on what materials are used, and what can and what cannot be expected from the molding.

Central Ohio Tours N. American Aviation

A. P. Young

The February meeting of the Central Ohio Section of the Society of the Plastics Engineers consisted of a tour through the plant of North American Aviation, Inc. After a welcome by Mr. E. K. Fry, Superintendent of the Columbus branch, members of the different departments explained their operations. To tie the discussion together, they followed one particular part through from design and selection of material to the completed part. Mr. Hesse, of the Material and Process Group discussed problems of design and selection of material. Mr. Kember explained Tool Design problems and processes, and Mr. DeVore explained Tooling operations. Finally, Production Operations were discussed by Mr. Cerquettini of the Production Plastics Group.

Then on a guided tour through the plant, the operations were observed and explained in detail. The tour also included the assembly line of the AJ Navy Attack Bomber.

The Section wants to thank North American Aviation, Incorporated, Mr. Fry, Mr. Cerquettini and all the many others who worked to make possible this very interesting meeting.

AROUND THE WORLD

★

AUSTRALIA

AUSTRALIAN PLASTICS

Vol. 8, No. 88, November 1952

Abstracter: Albert Lightbody

PLASTICS VERSUS ZINC DIE-CASTING (Reprinted from "Plastics")

A comparison of advantages and disadvantages of plastics in place of zinc die casting. The increase in cost of the zinc die casting alloy has placed plastics in an excellent competitive position.

PHENOLIC RESINS AND FILLERS by Wyman Goss

Reprinted from SPE Journal.

OPERATION EVOLUTION IN DE-INFORCED PLASTICS by G. M. Dick

Reprinted from Canadian Plastics. Developments leading to a plastics compressor housing.

EXTRUSION OF VINYL FILM by Albert M. Stover

Reprinted from The Journal of Society of Plastics Engineers.

STYRENE COMPOUNDS AS NEW TOOLS FOR INDUSTRY by Frazier Goff

Presented before S.P.I. Annual Conference, 1952. The use of special styrent compounds such as the styrene-acrylonitrile copolymers, rubber plasticized polystyrene and styrene in such uses as packaging, fly screens, special fabrics, cable insulation, refrigerator frames, battery cases, sound records, etc. are discussed.

★

FRANCE

INDUSTRIE DES PLASTIQUES MODERNES

Vol. 5, No. 1, January 1953

Abstracter: Hans Mayer

GALVANOTYPE by Paul Royer

In this first of a series of articles on "Plastics and Printing Matrices" the author describes the preparation of printing forms by the electrogalvanic buildup on thermoplastic masters, the backing up of the thin metallic shell and the finishing for use in the printing press.

POLYSTYRENE, COPOLYMERS, AND COMBINATIONS OF POLYSTYRENE AND OTHER POLYMERS OR COPOLYMERS

It is described how the desired physical properties of a product manufactured from Polystyrene can be influenced by three methods.

(a) by a modification of the process of polymerization,

(b) by the creation of copolymers or tripolymers of styrene and other chemical substances,

(c) by the combination of other polymers or copolymers with polystyrene.

To illustrate this statement specific American molding materials like Koppers X 8, Monsantos Cerex, Bakelites BMC II are discussed in regards to their specific physical properties created by one of the above methods.

THE EXTRUSION OF NYLON

Abstract of a publication on the same subject by the Field Service Laboratory of E. I. Dupont with comparative figures for the French Product (Rhodiaceta).

MEASUREMENTS OF THE HEATING CAPACITY OF INJECTION PRESSES by C. B. Beyer and R. B. Dahl

This article is a reprint of a publication of the Dow Chemical Company.

★

GERMANY

KUNSTSTOFFE

November 1952

Abstracter: Anne Schwend

Dr. Kurt Hultzsch, Wiesbaden-Biebrich — About the context and fixing the limits for poly-reactions (A discourse held previously in Vienna in September 1951, in Stockholm in November 1951 and in Frankfurt Main in May 1952).

New methods for the production of macromolecular compounds which it is hard to place in the existing scheme of plastics materials divided into polycondensates and polymerizers, seem to require another division. Hence, the 6th Convention of the German Specialists Group for "Plastics and Caoutchouc" initiated a discussion of the basic precedents. The article does not aim at setting narrow limits for poly-reactions, but rather to show the points of contact and the transition stages. On the basis of the context shown by the author, there is a gradual transition from polycondensation to polymerization. The first group in between the two and next to the "genuine" polycondensates, i.e. those polycondensates which can be recognized distinctly as such, would be those poly-addition products whose formation takes place with or without catalyzers under migration of hydrogen and always requires two different components. Then, next would come those products from certain heterocycles according to the principle of ion chain polymerization, that is without migration of hydrogen. These products still show hetro-, oxygen-, sulphur or nitrogen atoms in the newly formed chains and form exclusively from similar or related monomers. On the other hand, they represent the intermediate transition stage to the "genuine" polymers which are also formed from similar but non-saturated monomers through ion chains or radical chains and whose newly formed chains consist exclusively of carbon atoms. (See Diagram "Abb. 11." Page 390).

Dr. Albert Petz, Ludwigshafen — Fibre Plates — a new material.

The shortage of wood has led to the pressing of plates from wood chips and shavings with the help of binders (using almost exclusively urea-formaldehyde resins up to now). These plates are dry-processed which leaves the wood fibre structure nearly a hundred percent intact. The properties and most important production processes for such fibre plates are being discussed.

Editorial — Convention of the Plastics Industry and Plastics Fair in 1952.

The success of the Plastics Fair held in Duesseldorf in October surpassed all expectations. 245 firms exhibited in six halls; there were counted 31 producers of raw materials, 115 molders for semi-finished and finished products, 63 manufacturers of plastics machinery and 10 manufacturers of tools. 165,000 visitors saw the fair; this number comprises 14,000 visitors from all parts of the world. The commercial success of the fair was fair to very good. There were no sensa-

tional news which would have surprised those familiar with the plastics industry.

Numerous new models were to be seen among the machines exhibited which showed a high degree of perfection and adjustments to the manifold requirements and left no doubt about their competitiveness.

Dr. Heinz Voigt, Darmstadt — Dielectrical Properties of Plasticized Polyvinylchloride at Frequencies of .1 to 1000 MHz.

By means of a specially developed "four capacities bridge" (See circuit diagram "Abb. 1", Page 395) the dielectric constant and dielectric loss factor in plasticized polyvinylchloride at frequencies between .1 and 1000 MHz as well as temperatures of 20 to 80°C are being investigated. Dioctylphthalate, dioctylsebacinate, Edenol PV and tri-kresol-phosphate serve as plasticizers. The medium dielectric relaxation periods result from those frequencies having maximum loss angles. Entering their logarithm above the reciprocal of absolute temperature will result in curves which show several points of interest as far as activating energy is concerned. With various plasticizers these amounts of energy are dependent on temperature. Finally, the influence of plasticizers on the dielectric constant is discussed.

R. Nitsche and G. Ehlers — International Standardization of Plastics

A brief report about the Convention of "Technical Committee TC 61 Plastics" of the ISO at Torino, October 2nd to 4th, 1952, and the subjects dealt with by the various subcommittees.

G. M. Kline — Mechanical Properties and Stability of Molded Laminates

An abstract from an article as appeared in Modern Plastics, August 1951, pages 113/124/182/189.

Ing.-Chem. Heinz Anders, Berlin-Gruenheide — Production of Kumarone Resins and the like Materials upon Refinement of Cyclic Hydrocarbons

The properties and sundry ways of polymerization for different products are described. Due to their properties Kumarone resins are used in the lacquer and paper industries.

M. Stel, F. M. Jacobs and D. Schriek — Determination of the Punchability of Hard Paper Plates

This report is issued by the Plastics Laboratory of the Philitefabriek N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands.

The working of hard paper plates often presents difficulties due to the unavailability of information on the most favorable conditions for punching. The above company has, therefore, worked out a scheme whereby it is possible to ascertain the hardness of the material during the process of punching. As a result, the context between hardness and quality of the punched products was investigated.

Dipl. Ing. Werner Schmitz, Siegburg — Welded Blowers of Rigid PVC.

Welded blowers of rigid PVC were developed for the chemical and related industries. Flow technical principles are observed and designs do not only meet the standards and requirements of this plastic material, but are simple and good in appearance. Designs executed are being described.

W. Goss — Modified Plastics

Excerpt from the April 1952 issue of SPE Journal.

This reprint concludes with the information the German plastics industry is working hard on these modified phenolics. "Kunststoffe" hope to be able to report about the first types of German modified plastics soon.

W. A. Haine and W. M. Land — Influence of Working Conditions on Quality and Yield of Extruded Polyethylene Films.

An excerpt from an article that appeared in the February 1952 issue of Modern Plastics.

★

DER PLASTVERARBEITER

Vol. 3, No. 12, Nov. 1952

Abstracter: E. C. Bernhardt

THE ECONOMIC POSITION OF THE GERMAN PLASTICS INDUSTRY by G. Matulat

A general summary illustrating the recovery of the German plastics industry since the war.

POLYSTYRENE FOR PACKAGING

A survey of the principal advantages of polystyrene as a packaging material.

NEW APPLICATIONS OF AIR JETS FOR THE PRODUCTION OF PLASTIC COATINGS

Brief description of a paper coating machine. Air jets are used to spread the plastic emulsion or dispersion evenly over the surface to be coated.

A NEW RESIN FOR HIGH FREQUENCY APPLICATIONS

Specifications and physical data of Alberit 8291 So. are given. This resin is recommended where low dielectric losses are important.

THE APPLICATION OF PLASTICS IN INTERIOR DECORATING

Description of the uses of PVC film for wall coverings, upholstery, etc. Included is a description of the application of transparent, colored styrene building blocks for decorative mosaic windows. These little blocks are injection molded, hollow, one-inch cubes, whose surfaces are ribbed for maximum light diffusion. A large variety of colors are available. Windows or partitions of these blocks are put together using special fasteners. Attractive designs, trade marks, etc. can be assembled. Mosaics can be suspended from ceilings to diffuse light from above.

ON THE PROPER OPERATION OF HIGH FREQUENCY PREHEATERS by K. Brandenburger

A summary of elementary operating rules for the use of preheaters.

ELECTRODES FOR HIGH FREQUENCY WELDING

Guides for the manufacture and application of electrodes. Rules for the successful welding of film.

COOLING OF MOLDS by H. Spies

Illustration of difficult cooling problems on sharp protrusions inside mold cavities.

GERMAN PLASTICS APPLICATIONS

The trap under a sink is made of a flexible plastic material. The trap can be cleaned without opening by merely giving it a few squeezes, and running fresh water through the drain. There is no chance for corrosion.

A NEW FILM WINDUP

This windup automatically compensates for the diameter change of the spool, and maintains uniform tension. It operates without a clutch. Tension can be adjusted over a wide range.

★

GREAT BRITAIN

BRITISH PLASTICS, Nov. 1952

Abstracter: Herbert R. Simonds

EDITORIAL

New Outlook on Testing

Properties not considered too important in plastics application heretofore now are vital. In aircraft structures, shear strength, often referred to as the "torsional stiffness," is often regarded as the critical property. Many of the existing technics for testing have been taken over from the metals field and so cannot be applied with sufficient accuracy to polymers.

Research workers in England are becoming increasingly aware of the new problems in testing. The editorial then refers to an article on testing in this issue.

GUARANTEED QUALITY OF P. V. C. SHEET GIVES CONFIDENCE (3½ pages illustrated)

Advances made in improving the quality of p.v.c sheeting have been demonstrated at recent exhibits in London. Rainwear, tablecloths, curtain materials, household goods have been exhibited, showing great improvement both in color, design and physical properties.

A British Standard (B.S. 1763) has been published, laying down minimum quality standards for p.v.c. sheeting

and the tests that it must withstand.

To meet the standards, calendering has to be controlled within narrow limits and machinery for this precision work is expensive. A calendering plant alone costs up to 100,000 pounds. At present there are only two manufacturers of p.v.c. resin in Great Britain, although a third plant will go into production shortly. The present output of p.v.c resin for the manufacture of sheeting is estimated at 10,000 tons a year. Annual output of sheeting is about 50,000,000 yards. Raw material consists of 60% resin and 40% plasticizer. Applications for p.v.c. sheeting include surgeon's aprons, clothes-hangers, lifebelts, cushions, tobacco pouches, and many other similar uses.

PLASTICS AID IN CONSERVATION OF OLD PAINTINGS by Dr. A. E. A. Werner (4 pages illustrated)

In the past traditional materials used in conservation have been of vegetable or animal origin such as beeswax, natural resins and balsams, and animal glues. Recently, the use of plastics has been making great strides in this field. A painting may be regarded as a stratified object, usually with four layers; the support, the ground, the paint layers, and the varnish.

By means of exaggerated sectional drawings, the technic of conservation is described. One answer has been found in the use of alkyd resins modified with an oil of high linoleic acid content and containing only a small amount of linolenic acid. A synthetic alkyd based on phthalic acid and glycerol modified with tobacco-seed oil appears satisfactory from preliminary work.

Two types of adhesives have been used in picture conservation. Mixtures of beeswax with dammar, Venice turpentine or gum elemi represent the older types. Recently, new synthetic resin adhesives have been replacing these older methods. Two examples illustrate how technics in conservation have been improved by the new synthetics. The ideal material for transfer, that is, re-attachment of a painting to a new support is an adhesive of the ethoxylene type, such as Araldite 101. This is obtainable as a cold-setting viscous liquid, which hardens by a chemical reaction not involving the elimination of any volatile by-products. The second example involves the use of aqueous emulsion adhesives, based on polyvinyl acetate plasticized with butyl phthalate.

THE PHYSICAL TESTING OF THERMOPLASTICS, A Critical Survey of Current Methods by J. J. Millane (7 pages with graphs, charts and tables)

This article points out difficulties in the evaluating of the physical properties of high polymers and explains the importance of carrying out tests over a wide range of time, temperature and stress.

The paper discusses some of the more important physical tests carried out on thermoplastics. Each of the more important tests is analyzed and its shortcomings described. For instance, the impact test is a measure of the ability of the material to withstand suddenly applied stress, but the speed of applying such stress is usually ignored in the familiar falling weight or other test methods.

Similar shortcomings are pointed out for the softening point test, flow temperature gaging and complications due to plastics changes.

LINEAR POLYPHOSPHATES, A Group of New Resins by H. Zentfman & H. R. Wright (3 pages with charts and tables)

The monomeric esters of phosphoric acid, particularly of the aromatic series, e.g. tricresyl phosphate and triphenyl phosphate, have found widespread applications in industry in view of their high stability low volatility and wide solubility range. These new synthetic resins have been given the general name of Phoryl resins.

The resins are synthesized by a two-stage process in which a phenol is first reacted with phosphorus oxychloride to produce an aryloxphosphoryl dichloride which is then condensed with a molecular equivalent of a dihydric phenol.

Phoryl resins form clear, almost colorless, rather brittle glasses, which melt at temperatures between 60°C and 120°C, depending on their structure. In the molten state they form liquids with the consistency of a thick syrup. These resins show no sign of crystalline orientation when drawn into fibres and examined under x-rays.

Phoryl resins are insoluble in water, alcohols, aliphatic hydrocarbons and ether. All Phoryl resins are soluble in chloroform, ethylene dichloride, benzene and alcohol.

Possible uses for these new resins include replacement of Canada Balsam as an optical cement, keying coats for paint films, and as a primer coat for paint systems which have to withstand corrosive conditions.

NEW ADHESIVE FOR LAMINATE VENEERS (1 page illustrated)

A new adhesive allowing veneering to be done easily "in situ" has been developed under the trade name of Evo-Stik SH-12.

Makers claim that with this adhesive wall laminates such as Formica may be put on plaster wall surfaces by hand. Doors may be covered without even removing them from their hinges. Panels are supplied 9' x 4' and are applied purely by hand pressure. The wall surface is brushed with a hard brush to remove dust and loose powder and the panels are wiped over with a clean dry rag.

PLASTICS APPLICATIONS (4 pages illustrated)

Among the applications cited are the following: a cistern float, a large grill for a radio, laminates for use on shipboard, fluorescent lighting diffusers and the usual run of portable radios and record players.

SOME ELECTRICAL AND OTHER PROPERTIES OF GLASS REINFORCED PLASTICS (4 pages)

By varying their resin binder a wide range of properties is obtained from glass-cloth laminates.

TRADE NOTES AND NEWS

Export of plastics materials in September jumped to 2,668 tons as against 2,588 in August.

The range of Cellobond synthetic resins has been extended to include polyester resins for bonding glass fiber at low temperature.

Pilot quantities of a new polyester

STRUCTURE AND PHYSICAL PROPERTIES OF PHORYLS 70, 1, 2 and 3

Code Number of resin	Softening temp. °C (ball and ring method)	Intrinsic viscosity g. 100 cc.	Density at 20°C
Phoryl 70	60	0.21	1.36
Phoryl 1	120	0.21	1.35
Phoryl 2	115	0.30	1.34
Phoryl 3	100	0.28	1.34

One of the most interesting properties of Phoryl resins is their very good adhesion to a wide range of surfaces, including metals, glass, synthetic polymers, wood, cloth and asbestos.

TENSILE STRENGTHS OF PHORYL RESIN METAL AND GLASS BONDS (LB. SQ. IN.)

Resin	Steel	Copper	Brass	Duralumin	Glass
Phoryl 1	1,500	1,300	1 250	1,000	650
Phoryl 2	1,550	1,600	1,100	950	1,500
Phoryl 3	400	750	250	700	—
Phoryl 70	1,700	1,900	1,800	1,850	1,400
Phoryl 80	2,600	1,950	3,200	2,200	2,400
Phoryl 23	—	—	—	—	1,550

resin by Catalin, Ltd., are now available. It is called Resin 4778. No monomer addition is required and the resin can be hardened at room temperature by adding a catalyst.

January 1953

EDITORIAL: (5 pages with charts) Recession in plastics sales in the United Kingdom in 1952 is thought to be temporary and there is much optimism concerning 1953. Export sales in 1952 fell off approximately 10,000 tons, valued at three million pounds. The recession in thermosetting materials was more marked than in the thermo-plastics. The ureas showed the greatest drop, reaching a 45% decrease in the June quarter. Nylon molding powder became more freely available during the latter half of 1952.

The chief interest was in the production of bearings, gear wheels and small engineering components designed as replacements for phosphor-bronze and other metals. The United Kingdom output of film and sheeting reached approximately 50 million yards with twelve companies doing calendering. 1952 showed a drop of 30% in rainwear and about 3% in packaging and tablecloths. On the other hand toys increased and production of cut lengths held level.

Table I gives an indication of the production of some plastics materials during recent years.

POLYETHYLENE TEREPHTHALATE FILM by R. A. Hudson (4 pages with graphs)

This new material is still in the pilot plant stage but some is being offered for experimental purposes. A pilot plant for its manufacture is being erected by the Plastics Division of Imperial Chemical Industries, Ltd. and production is expected by the middle of this year. Polyethylene terephthalate is the polyester formed by the combination of ethylene glycol and terephthalic acid with the elimination of water. In practice it proves to be more convenient to use the diethyl ester of terephthalic acid and eliminate methanol by ester interchange with ethylene glycol. The polymerization is taken to the stage where the melt has a viscosity, at 280°C, of from 2,000-5,000 poises, depending on the use for which it is intended.

PROPERTIES OF POLYETHYLENE TEREPHTHALATE FILM

Specific gravity	1.39
Water absorption % by weight, prolonged immersion in liquid water	0.5
Melting point 265°C	
Tensile strength at break, lb sq. in.	25,000
Elongation at break, %	50
Good resistance to mineral acids including concentrated phosphoric acid, but decomposed by concentrated sulphuric.	
Moderate resistance to alkalis, excellent to oxidizing agents.	
Excellent to organic compounds with the exception of phenols and chlorinated phenols.	
Dielectric strength volts 0.001 inch	4,500

A study of the properties of this new resin shows that it combines good resistivity and dielectric properties with good mechanical properties. Considerable attention has been given to the possibility of using this new film as a photographic base. The perfection of surface which can be obtained indicates that base film quality is possible.

PLASTICS APPLICATIONS (4 pages illustrated)

Among the items of interest this month are the following:

(1) Door knobs

(2) Surgical use of nylon

(3) Cable straps used in switch wiring

(4) Enclosed lighting fixture has part of conduit assembly

(5) Venturi forms in chemical plant equipment

(6) Indicator arms for motor vehicles.

SHELL MOLDING (5 pages illustrated)

This is a good description of the process as used in foundries, which process has been described many times in this country. The article states that if the annual turnover of one million tons of foundry sand could be converted to shell molding, it would reduce the turnover to 100,000 tons. Assuming a resin content of 7%, 7,000 tons of resin would then be absorbed each year in this application. The process is well illustrated, showing mixing of the sand with special resins which have been developed by Bakelite, Ltd. A notable increase in dimensional accuracy of the castings is one of the chief advantages of shell molding. It is possible to reduce tolerances ten times; that is, from 0.03 in. for sand casting to 0.003 in. for shell molding.

PHYSICAL PROPERTIES OF FLAME - RETARDANT POLYTHENE by E. I. Cooke (1½ pgs.)

In this article advantages and disadvantages of flame-retardant polythene are given. A typical example of flame-retardant material is given as follows:

Grade 2 Alkathene	56 parts
Timonox (pigmentary grade of antimony trioxide)	28 parts
Cerechlor 70	15 parts
Antioxidant mixture	1 part

GLASS-REINFORCED PLASTICS (4 pages illustrated)

This article shows the general lines of similar articles which have been published in American magazines. It shows among other things, the unit used for making glass fiber and resin preforms. This unit is manufactured in England by Turner Atherton Co., Ltd., which company is associated with Turner Manufacturing Company of this country making similar units here. The British Company is the parent company. In this equipment glass fiber rovings are first cut to length, then mixed with resin, introduced into a chamber which has as its base a metal screen form over which the mixture of fiber and resin is deposited to develop the preforms. A strong exhaust below the screened forms can be regulated in such a way to cause a uniform thickness of the preform.

BLOW EXTRUSION OF THIN VINYL FILM (2 pages illustrated)

A brief description of a process by which 45,000 tons of calendered coating film is utilized in the United States each year.

★

PLASTICS

December 1952

Abstracter: A. T. Rexer

DYE TEST FOR MELAMINE MOLDINGS

Abstracts of a thesis presented by C. P. Vale for the Associateship of the Plastics Institute covering the investigations and their result for a satisfactory method of testing for the degree of cure for melamine-formaldehyde moldings, the sulphuric acid test being deemed unsatisfactory. These investigations led to the development of a dye staining test, which is based on the fact that undercured moldings immersed in a boiling solution of a suitably selected dye absorb color whereas fully cured moldings remain largely unaffected. By testing a series of moldings having different cure times, the optimum molding time can be determined. Local patches of insufficient cure, caused by faulty mold design or molding technique can also be readily detected. The article is illustrated with colored photographs.

CORONATION SOUVENIRS

Illustrations of some of the Coronation souvenirs made from plastics which have been approved by the Council of Industrial Design.

CELLULOSE ACETATE BUTYRATE Part I by E. E. Halls

A comparison of cellulose acetate butyrate and cellulose acetate with regard to their properties in molded components. It contains five tables of data.

(Please turn to Page 46)

THE *Injection* MOLDERSCOPE

By A. R. Morse

President, Injection Molder's Supply Co.

The recent price increase of something over 30% in a leading make of injection machines brings the cost of a popular 8 ounce machine to about 2½ times its rated capacity in ounces! When an 8 oz. machine creeps toward $20,000 installed there are many questions that will invariably come up in the molder's mind — not only questions about die space, about plasticizing capacity, about maintenance costs etc. but about when and how to buy a new machine — and perhaps the idea may take root that it is getting to the point where one can build a machine for about the same or less money than it takes to buy one! The question has come up several times recently as to whether by buying a feed-weigher and a heating cylinder (cost: circa $2500) and by building the rest of the machine locally, some cash outlay could not be saved.

Some did I say? I have just run through a detailed calculation with one molder friend where we figured the saving at over $5000! Of course some fancy frills might be omitted, but I think that such a home-made machine could match any 12 oz. in production. There is always the question of delivery of pumps, motors, weldments etc. but honestly from what I hear, this last price jump may be the straw that breaks the camel's back. At press time it is still a question whether the other injection machinery makers are going to follow suit in this price jump or not. The recent strides made by HPM and Lester in injection machine design would merit the increase and deserves special notice. These concerns are more closely tuned to the molder's needs than ever before in their history, and their managements have become more alert and quicker to recognize what should be changed and what should not.

If Reed and Watson were ever the leaders in the race toward a better injection machine, they are going to have to look to their laurels in 1953 from all one hears about the shuffling going on among the Big 5.

This matter of which is the BEST injection machine is a delicate topic indeed. One hears all kinds of stories, but no trade paper dares so much as mention the matter of actual machine comparisons any more. What a topic for a Prize Paper! What a controversy! But what a lasting contribution if the various injection machines could be related to some standard! I am afraid, however, that we are farther away from any such comparison than at any time in the history of the industry. No article would be more unprintable than one comparing injection machines, and the molder is just going to have to sift out this information for himself.

If you take the tracings of the various heating cylinders from 6 of the leading 12 oz. machines and hold them over a tracing glass you will see what I mean. The variation in capacity is manifest. — it simply cannot be denied when you see it in black and white. Of course if this information were put into editorial form, it would plainly have to be reviewed in the light of the advertizing budgets involved, and I doubt if it would ever get printed. I for one who makes such comparisons almost daily in designing standardized heaters to gain extra capacity would not DARE publish the facts, and I used to be a pretty bold, outspoken guy at that! What molder would ever have occasion to compare heaters in such detail? Why, it is done very day on a job-rating basis, and unless a molder has more than one make of machine he is probably not even aware of the relative superiority or deficiency of his press, although job-swapping today is blowing away some of this smugness. Machines are being bought on a delivery basis these days, and new makes creep into shops with amazing results. Some go all out for the new machine, particularly if some of the men have had previous experience with them. Others never learn how to run the new machine, and sometimes it just sits there, or always seems to be broken down, and the run of bad luck can never be overcome.

At any rate, some interesting months lie ahead. Will injection machine deliveries open up? There are definite signs they will, maybe sooner than you think. Will injection machine prices of all makes go up? Probably they will from 10-15%, but not 30%. Will all these prices then head down? I would hazard yes, but not till later this year, or early next —and then only barring war or new controls or unanticipated government interference with economic laws. What about preplasticizing? Due to sharply increased costs (both original and operating) it is slow in taking hold, and will not sweep the trade as some people thought it might, at least not overnight.

Around the World

(Continued from Page 4...)

★

HOLLAND

PLASTICA, Vol. 6, No. 1

Abstracter: W. P. ter Horst

NATURAL RUBBER AMONGST SYNTHETIC HIGHPOLYMERS by A. van Rossem pp. 22-26

Natural rubber is a cis polymer of isoprene in which the recurring units are linked exclusively in the 1-4 position. The molecule shows great regularity, great mobility and can crystallize.

Synthetic GRS rubber and "cold" rubber are co-polymers of butadiene and styrene and are mixtures of cis and trans units which are linked in 1-4 and 1-2 positions. The molecule is irregular, mobility is less than for natural rubber and the polymer cannot crystallize.

The technical properties before and after vulcanization, such as calendering, tensile strength and reinforcement with carbon black are discussed and explained in the light of the configurations of the molecules.

★

MEXICO

MEXICAN RUBBER AND PLASTICS

Vol. XIV, No. 83, December 1952

Abstracter: John B. Ballard

THE PROBLEM OF RAW MATERIALS FOR PLASTICS IN SPAIN by F. Garcia Estartus

Discussion of the future of plastics in Spain, with particular reference to the availability of materials. Reprinted from The Plastics Review of Madrid, Spain.

January 1953

ECONOMIC ASPECTS OF THE PLASTICS INDUSTRY by H. A. Frank

The economics of plastics manufacturing, with particular reference to the Netherlands. Reprinted from the "Plastics Review" of Madrid, Spain.

POLYSTYRENES MODIFIED WITH RUBBER by Frazier Groff

Properties and possible uses of new polystyrene materials plasticized with synthetic rubber.

PLASTICS EDUCATION

The plastics program at Princeton University is described in a new brochure which may be obtained by writing to Louis F. Rahm, Director, Plastics Laboratory, 30 Charlton St., Princeton, N. J.

SECTION NEWS

Edited by
Stanley Bindman
Jamison Plastic Corp.
71 E. Sunrise Highway
Freeport, New York.

Chicago Talk on Temperature Control

M. A. Self

The Chicago Chapter of the Society of Plastics Engineers, Inc. met on February 11 for their monthly dinner meeting. Two very informative and interesting talks were given.

Mr. J. B. Higley, Field Engineer of Leeds and Northrup Company, spoke first and in his discussion entitled "Types of Temperature Controls for Plastics" he gave the various electric control means available. These, according to Mr. Higley, consist of the following:

1. Simple two position — ON-OFF — type
2. Proportional Type control.
3. Full Proportional Control.
4. Full Proportioning Control plus rate action.

The Full Proportional Control system is the most practical for the plastics industry when considering both accuracy and minimum cost.

Mr. C. N. Sprankle, Sales Manager of Extruded Products Division of Plax Corporation, gave "A Challenge to the Midwest Plastic Industry." He discussed the "growing pains" through which the polyester plastic industry has been going. In growing from a small to a very large industry, we are faced with the problems of standardization upon thickness, weight, and other variable factors of the plastic; giving the buyers a uniform product and at the same time to protect the manufacturer so that he is not squeezed from a price standpoint on inferior merchandise. Standards are established by the Government upon the request of a representation of the industry and the problem is ours. He planted many thoughts in our minds, regarding the possible ways of improving our industry in its rapid growth.

R. C. Smith will be moving soon to Peru, Indiana where he will act as Assistant to the President of the A. G. P. Corporation. The one regret of his friends in the Chicago Chapter is that we will not enjoy his presence on the Board of Directors for the coming year. Dick had been elected to the office of Secretary-Treasurer and this vacancy will now be filled by M. A. Self of LOGO, Inc. R. K. Gossett of Gossett and Hill will fill his vacancy as a Director. Dick has been with Bakelite Corporation here in Chicago the last few years, as a Sales Engineer.

Mr. Maurice Meltzer of Service Plastics has been chosen to serve as Chairman of the Committee contacting the Plastics Industry in the Chicago area on behalf of the 1953 Red Cross Drive.

Warden Ragen receives a gift radio from Charles Schiff after his address at the Chicago Section SPE.

January Meeting

The Chicago Section of the Society of Plastics Engineers, Inc. were pleasantly entertained on January 14 by Mr. Joseph E. Ragen, Warden of Stateville and Joliet prisons. In his talk, "A Trip Through Joliet and Stateville," Warden Ragen emphasized the relation between juvenile delinquency and adult crime. He indicated that a high percentage of today's prisoners have juvenile records and many of them are from broken homes.

Many interesting facts concerning prison life were given, including information on efforts to rehabilitate the inmates. Partly as a result of this endeavor, the prisons have become self-sustaining to a substantial degree. Through this effort, they furnish their own food and clothing and supply various requirements of other Governmental agencies. Nevertheless, each taxpayer contributes a considerable amount of money toward the maintenance of each inmate and it is increasingly important that each citizen do whatever possible to prevent juvenile delinquency and other forerunners of crime.

A short film completed our "trip" inside the grey walls.

Warden Ragen is distinguished as one of the nation's leading prison wardens. He has spent 30 years in penal work and his fearlessness is a by-word in prison circles throughout the country.

Polyester Boat Built at Newark Meeting

Ed Ackerman

February 11th was another successful meeting with over 124 members and guests turning out to hear a discussion of Polyester Resins by Dr. Irving E. Muskat.

Jack Pecktal, President of the Newark Section, opened the meeting with a brief welcome to the members and guests. The meeting was then turned over to Don Biklen, Program Chairman, who introduced the speaker, Dr. Muskat of Marco Chemicals, Inc., Linden, N. J.

Dr. Muskat delivered a most informative talk on the chemical nature of polyester resins and then discussed their basic applications. He described the new thixotropic resin which is a newcomer in the polyester field and during his talk constructed a polyester boat reinforced with glass cloth.

Some of the major points brought out in Dr. Muskat's talk were as follows: Polyester boats reinforced with glass cloth have been produced for six years and have more than proven their worth in service. The Navy has tested these boats to a considerable extent. A polyester glass fabric boat can be made in one day, while a comparable wood boat would take 3 months. Although it is difficult to puncture, the Navy equips each boat with a repair kit and trains personnel to make repairs when and if necessary.

Sport cars made from the same material are fast becoming popular, although they cannot compete in price or on a large scale production basis with the conventional metal cars.

One major advantage of Polyester glass fabric is its strength-to-weight-ratio. Where many of our molded plastics are 0.3 to 4 ft. lbs. per inch of notch, polyester reinforced with glass fabric displays about 40 ft. lbs. per inch of notch. The curing of this resin can be closely controlled by varying the amount of catalyst and accelerator. High production is possible since parts can be made in curing cycles of 10 seconds. The resins produced today have a working temperature of 500°-600°F. They can be cast conveniently. Some people feel that they can economize by loading the resin with sawdust, sand, floor sweepings, etc., but actually the volume only increase up to 8%.

Colors are easy to use with the polyester resins. Other merits to this material are resistance to moisture, chemicals, weathering, and abrasion. The material also exhibits fine electrical and cold flow properties. It is being used more and more for coating such items as wood, concrete, plaster and other porous surfaces. The new thixotropic polyester resins offer advantages where there is hand-lay-up work. This resin will remain immobile until agitated at which time it will flow freely.

One of the highlights of Dr. Muskat's talk was the molding of a 4-foot polyester boat both reinforced with glass cloth. A male and female form was used (also made from polyester glass) and a vacuum was introduced between the mold halves at the same time the resin was poured. A glass cloth preform had previously been cut and shaped. The boat was molded in an upside down position and the resin was poured along the lower edge. Suction was introduced at the topside, causing the resin to flow evenly up the sides and across the top. Within 10 minutes the boat was cured and removed from the mold. Such a molding process is widely known as the Marco Process.

An enthusiastic question and answer period followed Dr. Muskat's talk. All agreed that it was one of the most interested discussions held before the Newark Section.

Recent Developments in Compression Molding Discussed at Connecticut

David Mersey

The Bakelite Corporation can claim full responsibility for an excellent double barreled program at the February meeting.

The first barrel was a shot into the plastics world of the future, with the film, "Flight into the Future." This had all the embellishments of color and sound.

Mr. Edward Vaill then presented the major portion of the program, "Recent Developments in Compression Molding." This subject might be divided into two parts, namely, new compounds, and new applications.

The first new compound presented was the new, fast, curing, phenolic, BM-18750. This is similar to Durez 791 and Monsanto GP-1000. Because of its fast curing character, caution should be observed where this compound is used in transfer applications, or where preforms are r.f. heated.

The other new compounds is Bakelite's BMQ-11995, which is a glass filled phenolic. Though melamine is superior in arc resistance, this compound provided an excellent combination of chemical, electrical, mechanical, and heat resistant qualities. This compound has high shock resistance, and might therefore be classified as a high impact material. The glass content of this material comes in the form of roving (⅝" strands). Besides giving the high shock resistant characteristics, the roving tends to minimize the skin irritation which occurs where finely granulated glass is used as a filler. As an impact compound, the flexural and impact qualities increase as does the completeness of the orientation of the glass strands or roving.

Orientation is similar to the grain in wood, i.e., the degree to which the fibers align themselves in the direction required to produce maximum strength. Full orientation refers to the situation where all the fibers are parallel, and the breaking force is applied at right angles to the lay of the fibers; whereas, in zero orientation, the force is applied parallel to the lay of the fibers.

BMQ-11995 comes in a natural color, and makes an attractive, honey colored-finished part. Although designed primarily for compression molding, it may be transfer molded, but at a sacrifice in strength.

New applications are primarily in the field of large moldings. Mr. Vaill showed several specimens of furniture drawers, and in pointing out the merits of this application, suggested that the molded drawer eliminated many of the stages of manufacture from the tree to the finished drawer. Naturally such savings are passed on to the consumer. The drawers were light in weight, between four and five pounds. Being made with a phenolic compound, they are moisture resistant and would eliminate warping and sticking which usually plagues wood drawers in humid weather. The inner surfaces were smooth and highly polished, and lend themselves to easy cleaning. With no joints or seams or sharp corners, there was no place for dust or dirt to gather. The drawers were of the closed and open faced types. With the later, a wood panel is used to close the face, this panel matching the surface of the piece of furniture of which the drawer is a part, such as, occasional piece, desk, kitchen cabinet, etc.

Another new application, also in the furniture field, is in large outdoor cabinets, for portable refrigerators, bars, air conditioners, etc. One such cabinet weighs seventeen pounds. This supports the cooling unit, the inner housing, and whatever contents might be added by the user.

Looking back at the movie and the spoken portion of the program, one is forced to make only one conclusion, the plastics industry has done little more than scratch the surface of its potential market.

Southern California Officers

Front Row: A. Ray, Ray Products Co., House Committee; Bob Whann, North American Aviation, President; Clint Booth, Formica Co., National Committeeman; Joe Potoczky, Aarbee Plastics, Membership.
Back Row: Walt Kadlec, DuPont, Secretary; Austin Herbst, Irvington Varnish, Program Chairman.

Philadelphia Speakers Describe Work Of National Education Committee

A. J. Kissileff

Philadelphia Section in conjunction with the Area Section of SPI met at Franklin Institute February 24th. In presenting the speakers, Jack Stokes outlined briefly how Princeton University eventually recognized the need for education in plastics. Officials of Princeton, after consultation with SPE, and an intensive study of recommendations made by the Society, finally elected to prepare a curriculum for students desiring to enter this field.

To head the course and set it in motion Princeton selected Professor Louis F. Rahm who received his B.S.-M.E. at University of Michigan in 1921. His industrial training was gained at duPont, Picatinny Arsenal and the Burroughs Co. Prof. Rahm first began teaching at University of Illinois and in 1926 at Princeton. During the war he served as Plastic Engineering Group Leader with the National Defense research council. He is a contributor to various technical journals and author of a book "Plastic Molding." He will be remembered by many as a former Chairman of SPE's Educational Committee.

By setting up standards for educational courses, the University has been able to obtain the cooperation of the U. S. Armed Forces in development and research projects. A working pilot plant has also been installed and has reached the stage where Princeton is now supplying instructors for other institutions. The course, as outlined by Prof. Rahm is setup in two programs to cover both undergraduate and graduate students.

Professor Rahm advised this reporter that a complete resume, including explanatory charts and graphs will appear in an early issue of SPE Journal.

The next speaker was Professor Bryce Maxwell, instructor at Princeton in the Plastic Laboratories where he teaches the practical side of Plastics. Professor Maxwell received his B.S.M.E. at Princeton in 1943 after which he served with the U. S. Navy. At present he is a Research Associate at the University with a government grant to study the rheological properties of plastics. He is also an assistant Professor of Engineering in the Plastics School. He has served as Secretary to the SPE Educational Committee.

Professor Maxwell's subject "Crazing of Polystyrene" brought out causes of crazing, but went a healthy step farther by outlining ways to eliminate such crazing. He stated that this problem has been reduced materially by improved molecular distribution—elimination of residual monomer and changes in design of products to reduce strain to a much lower minimum. He pointed out the extreme importance of protecting surfaces of the finished part from organic materials which have a crazing effect on polystyrene. Other factors such as more careful design of molds, and the addition of surface coatings for better protection, according to Professor Maxwell, will be also of considerable aid.

Because of the nature of this meeting, invitations were sent to deans of all colleges in the area, suggesting they send faculty members interested in plastics to attend. While the turnout was not great, there was definite interest. As a result, consideration will be more serious and active in the near future of a program designed to increase college level effort to add plastics courses in this section of the country. It will be interesting to watch the developments.

For the first time in several years, Dick Bishop was not on hand. Because of illness Dick could not attend. Everyone wishes him a speedy recovery.

Walter Fuller has resigned his position with American Viscose Corporation to accept the role of Chief Plastics Engineer with Ocean City Manufacturing Company of Philadelphia, one of the industry's rapidly growing members.

Philly's March Meeting will deal with "Deep Drawing of Polystyrene Sheet," with Dow Chemical's Krepscott as the speaker.

George Koch, last year's local President has accepted the job of Chairman of the Annual Outing Committee. Judging from past experience, we can look forward to another relaxing and enjoyable affair.

Interest in the 1955 National Conference, to which Philly will play host is already beginning to run high. Because of the rapid increase in membership — 22 applications received since January meeting — it appears that all phases will have ample personnel to carry on the huge job of organizing the Convention.

Plastics Decorating Is Buffalo Topic

Arthur G. Scutt

Mr. Hamilton E. MacArthur of the Conforming Matrix Corporation of Cleveland, Ohio addressed the Buffalo Section of Plastics Engineers at their monthly meeting held Friday evening, February 20th.

Mr. MacArthur discussed many of the problems involved in the painting of plastic toys, decorative moldings and panels and manufacturers emblems. Plastics are painted to increase their eye appeal and generally many color combinations are used. The problems arise because of the masks or paint shields necessary to confine one of the colors to a specific area.

Mr. MacArthur's company makes precision painting masks by electro plating a form over the molded part. The forms are usually assembled with fixtures to accurately hold and seal the molded part during painting. Accuracies of one half a thousandths of an inch are commonly obtained in painting such things as emblems for automobiles and refrigerators.

During the discussion period following the talk Mr. MacArthur gave advice on many specific problems and showed many types of masks and the products resulting.

Furniture Drawers Molded of Phenolic Have Many Advantages

Trends in Molding Thermoset Plastics Discussed at Western New England

E. J. Sweeney

"Trends in Molded Thermosetting Plastics" was the program title for the Western New England Section's February 4th dinner meeting. Mr. E. Vaill, Manager of Bakelite Company's Hartford office spoke on phenolics.

The phenolic production has increased and is expected to continue to increase although the rate of expansion is not as rapid as some of the newer plastics. The trend is toward faster curing, larger molding, and in some cases, higher strength. The speaker discussed the advantages of a high strength glass filled molding compound that the Bakelite Company has recently developed. This material, designated as BMQ-11995, is a glass filled two step compound with excellent chemical, electrical and heat resistant properties as well as having high shock resistance and strength. Mr. Vaill showed sample moldings and compared the properties under various molding conditions. The material makes the strongest molding when the fibers are aligned in the direction required to produce maximum strength. BMQ-11995 is not yet available in production quantities. Samples can be obtained for development work.

The large phenolic moldings were illustrated by the Wonderbar now being molded for Servel, Inc., and an experimental one piece drawer for furniture. Mr. Vaill explained the advantage of this type drawer over wooden drawers. The drawers have the advantage over wooden drawers in cleaning, sticking and drying out at joints.

The melamine picture was presented by Mr. W. A. Ward of American Cyanamid Co. Mr. Ward showed slides on the various designs in Melamine tableware. He went into the history of this development briefly. He also showed examples of Melamine high temperature material and explained the molding technique.

The dinner and business meeting was held before the speaking program. Mr. E. Childs introduced the committee chairmen for the coming year. The members were also notified of the change in the Annual Dance from May to December. Mr. Ray Mazur spoke briefly on the membership program.

Indiana Group Sees Robots at Work

James O. Martin

The February meeting of the Northern Indiana Section was held at the Chamber of Commerce Bldg., Ft. Wayne.

The program consisted of a movie "Robots at Work," narrated by Lowell Thomas, and a very interesting presentation of the "Story of Automatic Molding" by Mr. S. S. Hellwell, the Chicago District Sales Manager, for F. J. Stokes Machine Co. of Philadelphia, Pa.

Due to the flu and a postponement of the meeting our group was much smaller than usual.

Therefore the meeting lent itself to informal discussion of the desirability of automatic molding, the necessary considerations of the piece parts and mold design planning to attain successful applications in thermoplastic and thermosetting molding. Several samples of automatically molded parts were displayed.

An informal dinner meeting at the Manochios Grill and Restaurant preceded the meeting.

JANUARY MEETING

The January meeting of the Northern Indiana Section of the Society of Plastics Engineers, Inc., held on January 9th in the Chamber of Commerce Building, Fort Wayne, Indiana, was called to order by our new president, Mr. Cecil W. Armstrong.

After Mr. Armstrong had been duly applauded, he then announced that the new officers for the coming year would be as follows:

Dr. Ivan Planck of the Indiana Technical College — Vice-President

Mr. Philip A. Leonard of the Wayne Plastic Corporation — Secretary-Treasurer.

The next order of business was the presentation of a certificate of recognition to our past president, Mr. Ferris A. Newman, which was presented by Mr. Armstrong in appreciation of Mr. Newman's services.

Minutes of the previous meeting were read by the Secretary-Treasurer and approved.

The speaker for the evening, Mr. Rex Bradt, President of Fiberfil Corp., Warsaw, Indiana was then introduced by Mr. Armstrong. Mr. Bradt's talk was a discussion on the physical properties and uses of a new glass filled polystyrene material he has developed and sample parts molded out of Fiberfil were shown.

Manco Promotes Joseph Healey

Melvindale, Michigan, Feb. 10, 1950 — M. A. Nichols, president of Manco Products, Inc., producers of Tru-Cast beryllium copper cavities and cores, today announced the appointment of **Joseph P. Healey,** vice president, as general sales manager.

Healey, who has been with Manco for five years, will handle all sales in the United States, Canada, and foreign countries. He is chairman of the membership committee of the National Council of the Society of Plastic Engineers. He will reside and have his headquarters in Buffalo, New York.

New York Topic "In-Plant Training Programs for Large and Small Plants"

A. M. Merrill

Approximately 65 members and guests of the New York Section attended a regular dinner meeting on February 18 at the Gotham Hotel, and heard a talk on "In-Plant Training Programs for Small and Large Plastic Plants" by Bleick von Bleicken, president of Management Services Publications, Inc. Robert Sherwood, plastics consultant, had been scheduled to speak on "Slush Molding—Its Techniques and Future," but was unable to attend the meeting owing to illness. Movies of actual plant operations involving slush molding were shown, however, with a running commentary by Irvin I. Rubin, Robinson Plastics Corp. and Section program chairman, as well as by other Section members in the absence of Mr. Sherwood.

Mr. von Bleicken stated that the present trend is towards the use of operating management instead of specialists for training plant personnel. The need for training programs can be related to management appraisal of national manpower needs and possible shortages. The speaker emphasized that smart management anticipates manpower shortages and does not wait for them to develop. A given company's manpower needs can be estimated on the basis of its production and sales volumes, turnover of experienced labor, and the effect of the military draft on existing personnel.

In planning a training program, the following factors are important: (1) interest must be aroused in the trainees; (2) instruction should be given at the proper intelligence level and be aimed at specific objectives; (3) the training should satisfy both the trainer and trainee; and (4) management should practice what it preaches in the instructions. Adequate job descriptions, wage structures, evaluation and upgrading methods, and training follow-ups or controls are also of great value. In conclusion, Mr. von Bleicken mentioned aids provided by city and state education departments, trade schools, libraries, and consultants in planning and carrying out training programs.

Section president Saul Blitz, Noma Electric Corp., presided over the business session preceding the talk, and introduced the guests present, including Joseph P. Healey, Manco Products, Inc., and national membership committee chairman. Stanley Bindman, Jamison Plastics Corp. and national vice president, reported on the recent national conference in Boston.

The rapid growth of the Society for the past few years was pointed out, and estimates indicate a potential membership of 10,000. Mr. Bindman also mentioned the formation of a national publicity committee, and a national technical consulting committee to aid members in solving their technical problems.

Harold H. Schwartz, Empire Brushes, Inc., and chairman of the Section's educational committee, reported on the progress of the plastics vocational training program being undertaken in conjunction with the New York City Board of Education. A curriculum for the course has been prepared by committee members, and much of the necessary equipment has been obtained. Further funds are needed to purchase the remaining equipment, and a resolution was passed by the Section to contribute $250 from its treasury. Additional funds will be solicited from member companies.

Table favors were distributed through the courtesy of Nova-Plas Mfg. Co., Inc., and the meeting closed with a drawing for a door prize contributed by Celanese Corp. of America.

Ten new members were added by the Section during February, as follows: Carl L. Beal, Ideal Plastics Corp.; Norman R. Davis, Majestic Molded Products, Inc.; Joseph G. DeVito, Gilbert Plastics Co.; Joseph Esak, Poly Plastic Products, Inc.; Delbert F. Jurgensen, Congoleum-Nairn, Inc.; Myron Maibrunn, Robinson Plastics Corp.; T. G. Nock, Shell Chemical Corp.; Julian Paul, Carbide & Carbon Chemicals, Co.; Fred F. Petersen, Westchester Plastics Co.; and Irvin L. Tubb, International Business Machines Corp.

Krilium and TV At Miami Valley

John L. Russell

Miami Valley Section, SPE held its first meeting under its new President, Joe Merke. This consisted of a dinner meeting on Thursday, February 5 at the Wishing Well, Centerville, O. The program chairman for the evening was Otto Fiedler and the principal speaker was Mr. I. O. Salyer, of the Monsanto Chemical Co., Central Research Laboratories in Dayton. Mr. Salyer showed a 20 minute color movie and also gave a short talk on the development of Krilium together with a demonstration of this new soil conditioner.

The group toured the new RCA tube plant in Cincinnati on Thursday, January 8, and witnessed the manufacture of television tubes. The visit was a very interesting one and we want to sincerely thank the following RCA personnel for helping to make the evening a pleasant and instructive one: Messrs. Duncan, VanWagoner, Hanbold, Royalty, Kaeser, Swander and Steggins.

Miami Valley Section is justly proud of the elevation of one of its boys and former President of the Section to the National Presidency of of the Society of Plastics Engineers, Inc. Walter Oelman, elected to this high post at the recent Annual Technical Conference held at Boston, has served Miami Valley Section well and we know that he will be a real leader for the National Organization.

John Brierley, who has served as a Director for Miami Valley Section, has transferred his affiliation from the Bakelite Corp. as Sales Representative, to the Buckeye Molding Co., Miamisburg, O.

Byron Nelson, of the National Cash Register Co., Dayton, was recently honored by his selection as speaker at the Eighth Annual Technical & Management Conference, Reinforced Plastics Division, Society of the Plastics Industry (SPI) held at the shoreham Hotel, Washington, D. C., on February 18. Mr. Nelson spoke on "Finishes for and Surface Qualities of Glass Fiber Reinforced Moldings." He also participated in a Panel Discussion on Case Histories of Successful Products, by talking on Parts for Accounting Machines.

Our best wishes for a speedy recovery to Charley Selz who is recuperating from a recent serious illness.

Plastisol Bulletin

An extensive group of plastisols, designated the Hysol 3000 Series, is described in a new four-page bulletin published by Houghton Laboratories, Inc. These plastisols are dispersions of high molecular weight polyvinyl chloride resins in selected liquid plasticizers.

Copies of the bulletin on the Hysol 3000 Series of plastisols can be obtained from Houghton Laboratories, Inc., Olean, N. Y.

Phenolic Molding and Properties of Glass Filled Phenolic Interest Detroit

Emil R. Gazdick

The Detroit Section of the SPE will have a windfall for their March meeting. We will play host to a National Council meeting to be held in Detroit on March 27th., at the Rackham Memorial Bldg.

The Section dinner will also be held at the Rackham Memorial Bldg. on the same date. Walter Oelman our National President along with those National Directors who are chairmen of National committees have kindly consented to give this section a review of the accomplishments of the Society to date and the outlook for its growth in the future. The members will have the rare opportunity of having their questions answered personally by the men responsible for the guidance of the Society this year.

This March meeting follows another exceptional dinner meeting which was held at the Rackham Memorial Building on February 20th. Mr. Edward F. Borro, development engineer for Durez Plastics and Chemicals, Inc., of N. Tonawanda, New York, presented a paper on "Compression and Plunger Molding of Phenolics." His paper was supplemented with "Procedures and Properties of Glass Filled Phenolics."

Mr. Borro supplemented his talk with slides correlating the various variables in the construction of compression and closed molds and their effects on thermoset molded parts.

In his discussion of procedures and properties of glass filled phenolics various samples of different types were exhibited and their processing properties were described.

This section is indebted to Mr. Borro for his technical presentation of a subject of interest to all molders.

Our section president Mr. Bill De Galen has chosen the following committee chairmen. Along with these chairmenships Mrs. Mary Denny of C. H. Whitlock Associates, Inc., has kindly consented to act as recording secretary.

Program — W. R. Walsh — Monsanto Chemical Company; **Nominating** — A. J. Tripp — Detroit Plastic Tile Company; **Election Inspection** — Ed McElligott — Swedish Crucible Steel Co.; **Finance** — Sam Paul — Motor City Plastics; **House** — Roy Smith — Yardley Plastics Co.; **Membership** — Carl Whitlock — C. H. Whitlock Associates, Inc.; **Credentials** — Iver Freeman — Reed Prentice Machine Company; **Publicity** — E. R. Gazdick — Evans-Winter-Hebb, Inc.; **Educational** — E. W. Tillotson — Wayne University; **Professional Activities** — Gordon Thayer — Dow Chemical Company.

Thomas E. Orr Award Placques Are Ready

Frank A. Martin

The Cleveland-Akron Section met for dinner at the Spanish Tavern, Brecksville, Ohio on February 23. In contrast to the usual custom of having a technical speaker, the program provided by Sherman Crawford was an excellent film on the "Highlights of the 1952 Football Season of the Cleveland Browns." Lou "The Toe" Groza who last season set a new place-kicking record presented the film, and discussed the Browns operations generally. Cleveland being the football hot-bed that it is, the talk was very well received.

Two gold plaques, one for Case Institute of Technology and one for the University of Akron, commemorating the Thomas E. Orr award have been obtained for presentation. Mrs. Kathryn Orr who is now making her residence at the Lake Shore Hotel is affiliating with the Section as an associate member.

Major committee assignments for the year were announced as follows: Vic Blatter of National Rubber Machinery is Program Chairman, and Allen Valentine of Plastic Engineering is House Chairman. Other appointments will be announced later.

Laminated Wood and Mold Steel: St. Louis

George A. Stein

The attendance at St. Louis Section meetings is constantly increasing due to a revitalized program committee and excellent program preparation. Several new members have joined during the past month.

The February 24th meeting was preceded by an excellent dinner attended by approximately forty members and guests.

The speaker for the evening was Mr. George Power, Senior Project Engineer of The Formica Company, and chairman of the Cincinnati Section of SPE.

Mr. Power's talk was specifically directed to uses of PREGWOOD laminated wood products for decorative and industrial items, but also gave excellent coverage to uses of other high pressure laminates, including phenolic, melamine, and silicone products.

His talk was illustrated with colored and black-and-white slides, as well as with numerous samples which were passed among the audience for examination.

The meeting was closed with the usual attendance prize drawings. This session's prizes were donated by The Formica Company and Chris Kay Plastics.

JANUARY MEETING

Mr. George Brumbach of the Carpenter Steel Company of Reading, Pennsylvania spoke at the January meeting of the St. Louis Section of the Society of Plastics Engineers. He traced the history of mold steels from their inception to the present array of tailor made steels to fill almost every mold requirement of the plastics industry. Particular emphasis was placed on the procedures used in hobbing and the steels best adapted to certain types of cavities. He exhibited photos of a hobbed cavity for a large motor housing which was successfully done despite the deep draw and the intricate detail. According to Mr. Brumbach the only limiting factor of the size of the hobbed cavity seems to be the capacity of the hobbing press.

The January meeting was the largest meeting the SPE has had in St. Louis and was due to the efforts of the Carpenter Steel Co. and the large number of tool and die men in St. Louis who were present as guests.

Golden Gate Sees Decorative Fabrication

Richard M. Weber

The February meeting of The Society of Plastics Engineers, Golden Gate Section, proved to be a very lively one and it is felt that the members benefited greatly from the program offered.

Taylor & Art, Inc. of Oakland were our guest speakers. Aside from a remarkable exhibit of decorative fabricated pieces their artist, Mr. Cliff Johnson demonstrated various carving techniques. He employed electrical tools and drills and afterwards colored the pieces carved so we could see how the display pieces were made.

One member showed a ridiculous invention, brought into his shop that provoked much laughter.

The program was concluded with a talk, illustrated with numerous samples, on polyester resin castings of inclusions. Jim Rae of Industrial Plastics Service Oakland, was the speaker. Our attention was diverted from such objects as cast sea-horses, brains and abnormal teeth by Rae's usual humor. In all, the meeting was one of our best.

Electric Motors

(Continued from Page 34)

Development of Thrust Washer

An interesting development is the thrust washer used in electric motors to resist the endplay of the motor.

The original design for washers of this type consisted of vulcanized sheet fiber or phenolic sheet material.

With the requirement for quiet operation, a synthetic rubber washer is used which is housed in a steel cage. With this construction, very close endplay can be provided as well as quietness in operation.

A final development made possible by the use of plastics is a phenolic sheet material bonded to synthetic rubber.

Development of Blower

The original design of the blower is the cast iron or malleable iron type. For use in motors for hazardous locations, a brass or bronze type is supplied.

A die cast aluminum blower which can be used for many locations where certain corrosive conditions are present.

For many corrosive conditions, however, none of these materials are satisfactory and the molded blower has been used. (Figure 10)

This blower is made possible by the development of the melamines, polyester glass molding compounds, etc.

The main objection to the molded blower is the high tool cost for the molds.

Electric Motors 1900-1952

Figure 11 shows the comparative sizes of the motor built in 1900 and 1952 of the same horsepower rating.

It is apparent that reduction in size cannot be made without improvements in techniques and materials, and that plastics have played, and will continue to play, an important part.

Across the Desk

(Continued from Page 4)

a) A certain quantity (will be decided according to the offers we expect to receive through your kind cooperation) of Plastic foils or sheets made by leading American manufacturers.

b) Should it be possible to make indelible printings direct on the Plastic foils or sheets, we would then like to buy:

  a) Machines suitable for such printing works.

  b) Best qualities of Inks or Colours especially used for these works.

b) In the case that it is not possible to make direct indelible printings on the plastic foils, we would then buy

  c) Presses or machines for "plating" any kind of papers with plastic foil (as per enclosed samples) to one and or both sides or surfaces.

  In the latter case, no printing machines and inks or colours (as requested under paragraph 4) will be needed.

c) Detailed instructions on the use of the requested machines, inks or colours and plastic materials.

REFERENCES: Please apply to:

Banca Commerciale Italiana, Torino, Italy

Banca A. Grasso & Figlio, Torino, Italy

Banco di Roma, Torino, Italy

Manufacturers Trust Co., 378 Sixth Ave., New York, N. Y.

(with which bank our Mr. Felix A. Putaturo keeps a C/A)

Your kind cooperation in this matter will be much appreciated.

Ditta Felix A. Putaturo
Torino, Italy
Via Mentana 16

Gentlemen:

Mr. L. Lerch, plastics engineer, told me of the various items he had patented and made up samples of, which items are used for sporting goods and other automotive items as special attachments, and which items are primarily made out of plastics. A wide distribution of sales is assured him, if he could get said articles on the market, either thru a manufacturer, or thru a manufacturer-distributor, or both.

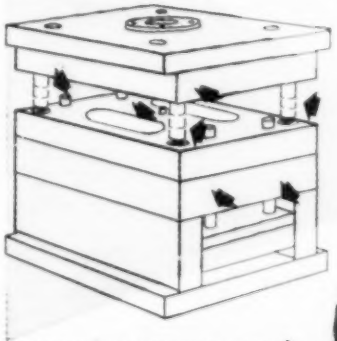
I have contact with numerous manufacturers who make woodflour in various grades, species and prices, and if you know of any of your members of your industry that use that item, let me know, and I will be glad to get in touch with said producers for said manufacturers.

Elmer E. Meyer

Plastics and Dielectric Materials, contains reprints of articles which appeared in Electrical Manufacturing from December 1949 to December 1952. Topics treated include fluorocarbon resins, silicone-rubber insulation, cast-resin embedments, ceramic materials, glass-fiber paper, organoboron resins, applying insulating varnishes. Anyone interested in the use of plastics as dielectric materials will find this little book worth his while. Ninety one pages, paper bound. The Gage Publishing Co., 1250 Sixth Ave., New York 20, N. Y. Price three dollars.

---

use IMS SILICONE BOMB as a GUIDE and KNOCKOUT PIN Lubricant



CLEAN! LONG LASTING!
Does Not Bleed Out....
Easy to Apply!
For all Cores, Cams, Pins and Moving Mold Parts
Lengthens Mold Life – Reduces Scrap!

PRICE PER CAN.....$ 2.00
UNBROKEN DOZEN.... 18.00
UNBROKEN GROSS.....197.40

Injection Molders Supply Co.
CLEVELAND 13, OHIO PENTON BLDG.

Plastics Literature

(Continued from Page 40)

law of diminishing returns but for the present, at least, is necessary to obtain a complete coverage.

REFERENCES*

1. Gray, D. E., "Controlling the Technical Report," **Bibliography of Technical Reports,** 16, 141 (1951).
2. "Availability of USAEC Research and Development Reports," TID-4550, United States Atomic Energy Commission, Technical Information Service, Oak Ridge, Tennessee, Aug. 1951. Free.
3. Wilcox, J. K., "New Guides and Aids to Public Documents Use, 1945-1948"; **Special Libraries,** 40, 371 (November 1949); 406 (December 1949).
4. Ball, N. T., and Flagg, C. R., "Searching United States Government Documents," **Advances in Chemistry Series,** No. 4, 70 (1951).
5. "Technical Information Activities of the Department of Defense," **Science,** 114, 653 (1951).
6. "Applied Research in the United States," National Academy of Sciences—National Research Council, Washington 25, D. C. March 1952. $1.00.
7. **United States Government Organization Manual 1952-1953.** Federal Register Division, National Archives and Records Service, General Services Administration. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. $1.00.

*A large number of the reports listed are Government publications available from the Superintendent of Documents at the prices indicated. The prices quoted are for delivery to addresses in the United States and its territories and possessions and in certain foreign countries that extend the franking privilege. In the case of all other countries, one-third the cost of publication should be added to cover postage. Remittances can be made very conveniently by coupons obtainable from the Superintendent of Documents in sets of 20 for $1.00, good until used. Checks and money orders should be made payable to "Superintendent of Documents, Government Printing Office" and sent to him with each order. The government Printing Office does not accept stamps in payment of orders.

8. **Monthly Catalog of U. S. Government Publications.** Superintendent of Documents, Government Printing Office, Washington 25, D. C. $3.00 per year.
9. **Selected U. S. Government Publications.** Superintendent of Documents, Government Printing Office, Washington 25, D. C. Free.
10. "Publications Relating to Plastics." Superintendent of Documents, Government Printing Office, Washington 25, D. C. February, 1951. Free.
11. "Bibliography of Reports on Plastics." SB-3 Revised. Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. January 1950. 50 cents.
12. **Bibliography of Technical Reports.** Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. $5.00 per year.
13. **Technical Reports Newsletter.** Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. 50 cents per year.
14. **Journal of Research.** National Bureau of Standards, U. S. Department of Commerce. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. $5.50 per year.
15. **Technical News Bulletin.** National Bureau of Standards, U. S. Department of Commerce. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. $1.00 per year.
16. "Publications of the National Bureau of Standards, 1901 to June 30, 1947," Circular 460; and "Supplementary List of Publications, July 1, 1947 to Dec. 31, 1951." National Bureau of Standards, U. S. Department of Commerce. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. $1.00.
17. "Plastics Research and Technology at the National Bureau of Standards." Circular 494. National Bureau of Standards, U. S. Department of Commerce, June 1950. Supplement, September 1952. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. 15 cents.
18. "Bibliography of Recent Research in the Field of High Polymers." Circular 498. National Bureau of Standards, U. S. Department of Commerce, September 1950. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. 20 cents.
19. "Index of NACA Technical Publications, 1915-1949." National Advisory Committee for Aeronautics, Washington 25, D. C. Free.
20. "Index of NACA Technical Publications, 1949-May, 1951." National Advisory Committee for Aeronautics, Washington 25, D. C. Free.
21. **NACA Research Abstracts.** National Advisory Committee for Aeronautics, Washington 25, D. C. Free.
22. **Monthly List of Publications and Motion Pictures.** Office of Information, Department of Agriculture, Washington 25, D. C. Free.
23. "List of Available Publications," M60. Office of Information, U. S. Department of Agriculture. July 1951. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. 40 cents.
24. "List of Processed Publications of the Bureau of Agricultural and Industrial Chemistry." Agricultural Research Administration, U. S. Department of Agriculture, Washington 25, D. C. January 1952. Free.
25. **List of Publications.** July 1 to December 31, 1951; January 1 to June 30, 1952. Forest Products Laboratory, U. S. Department of Agriculture, Madison 5, Wisconsin. Free.
26. "List of Publications on Chemistry of Wood and Derived Products," R238. Forest Products Laboratory, U. S. Department of Agriculture, Madison 5, Wisconsin. June 1951. Free.
27. **Nuclear Science Abstracts.** Atomic Energy Commission, Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. $6.00 per year.
28. Slesser, C., and Schram, S., eds., "Preparation, Properties and Technology of Fluorine and Organic Fluoro Compounds," McGraw-Hill Book Co., New York, 1951. $10.50.
29. "Armed Services Technical Information Agency, Document Service Center, Its Products and Services." Document Service Center, U. S. Building, Dayton 2, Ohio. Free.
30. "The Technical Information Division of the Library of Congress." Technical Information Division, Library of Congress, Washington 25, D. C. Free.
31. "Inflammability and Explosibility of Powders Used in Plastics Industry." RI-3751. Bureau of Mines, U. S. Department of the Interior, Washington 25, D. C. 1944. Free.
32. "Toxicity and Flame-Resistance of Thermosetting Plastics." RI-4134. Bureau of Mines, U. S. Department of the Interior, Washington 25, D. C. 1947. Free.
33. "List of Publications of the Bureau of Mines." 1910-1951. Bureau of Mines, U. S. Department of the Interior. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. $2.00.
34. "List of Publications of the Bureau of Mines," 1949, 1950, 1951. Bureau of Mines, U. S. Department of the Interior, Washington 25, D. C. Free.
35. "Dermatitis From Resin Glue in War Industry." Reprint 2471. Public Health Service, Federal Security Agency, Washington 25, D. C.
36. "An Outbreak of Dermatitis From Airplane Engine Cowling." Reprint 2472. Public Health Service, Federal Security Agency, Washington 25, D. C.
37. "Dermatitis From Plastics," **Industrial Hygiene News** Letter, 7, 6 (1947).
38. **Occupational Health** (Formerly Industrial Health Monthly). Public Health Service, Federal Security Agency. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. $1.00 per year.
39. **Prevention of Deterioration Abstract.** Prevention of Deterioration Center, National Research Council, Washington 25, D. C. $10 per year.
40. **Advance List.** Prevention of Deterioration Center, National Research Council, Washington 25, D. C. $10 per year.
41. "Plastics Materials-Basic Information Sources." Office of Domestic Commerce, Department of Commerce, Washington 25, D. C. 1951. Free.
42. "Chemical Statistics Directory, No. 2." Office of Domestic Commerce, Department of Commerce. 1949. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. 20 cents.
43. **Foreign Commerce Weekly.** Office of International Trade, Department of Commerce. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. $9.00 per year.
44. **Business Service Check List.** Department of Commerce, Washington 25, D. C. Free.
45. "United States Department of Commerce Publications, Catalog and Index." Department of Commerce, 1952. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. $2.75.
46. Donnelly, M. V., "Government Production Statistics As Source For Chemical Planning." March 1952. Chemical Division, National Production Authority, U. S. Department of Commerce, Washington 25, D. C. Free.
47. **Census of Manufactures—1947. MC28B. Industrial Organic Chemicals.** Bureau of the Census, Department of Commerce. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. 10 cents.
48. **Census of Manufactures—1947. MC39D. Plastics Products; Miscellaneous Manufactures.** Bureau of the Census. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. 10 cents.
49. **1950 Annual Survey of Manufactures. MAS-50-1.** Bureau of the Census, Department of Commerce, Washington 25, D. C. Free.
50. "Growth of Plastics Revealed by United States Census Statistics." Bureau of the Census, Department of Commerce, Washington 25, D.C. 1941. Free.
51. "New Product Opportunities, Available Patents, Plastic Products and Processes." Department of Commerce, 1949. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. 25 cents.
52. "Index and Guide to Enemy Patents." Office of Alien Property, Department of Justice, Washington 25, D. C. Free.
53. **Synthetic Organic Chemicals, United States Production and Sales, 1950.** Report No. 173, Second Series, U. S. Tariff Commission. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. 45 cents.
54. **Preliminary, Synthetic Organic Chemicals, United States Production and Sales of Plastics and Resin Materials, 1951.** U. S. Tariff Commission, Washington 25, D. C. Free.
55. **Preliminary Report on Production and Sales of Synthetic Plastics and Resin Materials.** Facts for Industry Series. U. S. Tariff Commission, Washington 25, D. C. Free.
56. "Plastics Products, War Changes in Industry Series." Report No. 28, U. S. Tariff Commission, 1948. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. 25 cents.
57. **Employment and Payrolls.** Bureau of Labor Statistics, Department of Labor, Washington 25, D. C. Free.
58. **Hours and Earnings.** Bureau of Labor Statistics, Department of Labor, Washington 25, D. C. Free.
59. "Employment Outlook in the Plastics Products Industry." Bureau of Labor Statistics, Department of Labor, 1948. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. 15 cents.
60. **Index of Federal Specifications and Standards.** 1951. Federal Supply Service, General Services Administration, January, 1952. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. 40 cents. Supplement 10 cents.
61. **Index of Specifications and Standards Used by the Department of the Army.** Department of the Army. April, 1952. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. $2.75 semi-annually (includes 5 monthly cumulative supplements).
62. **Index of Specifications and Standards Used by the Department of the Navy.** Bureau of Supplies and Accounts, Navy Department. April, 1952. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. $2.50 semi-annually (includes 5 monthly cumulative supplements).
63. **Index of Specifications and Related Publications Used by the Air Force.** Department of the Air Force. April, 1952. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. $2.75 semi-annually (includes 5 monthly cumulative supplements).
64. **Foreign Commerce Yearbook.** Office of International Trade, U. S. Department of Commerce. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. $2.25.

Plastics in Surgery

(Continued from Page 25)

plasma and many, many others could be cited to swell the list of places where plastics are invading the human body. However I think that as one works to try to replace any of the parts of the human body with our so called synthetic materials one inevitably ends up by having much greater respect for the complicated mechanism and the ideal material from which the body is actually composed.

References

(1) New York Times, March 2, 1952—"Plastic Tooth Fillings"
(2) John V. Niiranen, Naval Medical Bulletin, Vol. 47, No. 1 Jan, Feb. 1947
(3) John V. Niiranen, The Military Surgeon, Vol. 100, No. 5, May, 1947
(4) Drs. Rubin, Robertson & Shapiro—Plastics World, Dec. 1948
(5) Geo. Blaine, British Plastics—Feb. 1950
(6) Plastics in Surgery—Modern Plastics Encyclopedia (1949)
(7) Australian Plastics, Vol. 8, No. 80, March 1952
(8) "All Hands"—No. 388, June 1949
(9) Australian Plastics, Vol. 8, No. 83, June 1952
(10) V. T. Grindley and O. T. Claggett, Proc. Mayo Clinic 1949, 23, 385
(11) V. T. Grindley and O. T. Claggett, Proc. Mayo Clinic, 1949, 24, 346
(12) Science News Letter, Vol. 53, No. 25, p. 386, June 1948
(13) The Resinous Reporter, Vol. IX, No. 5, Sept. 1948
(14) Washington, D.C. Evening Star, Oct. 11, 1952
(15) Australian Plastics, Vol. 8, No. 85, August 1952
(16) Plastics News Letter, Dec. 10, 1951
(17) Plastics World, Vol. 10, No. 9, Sept. 1952
(18) H. H. Grindley and F. C. Mann, Arch. Surg. 1948, 56

Multi-Screw Extrusion

(Continued from Page 22)

mandrel and forces the PVC pipe against the former box. Water is constantly circulating through the jacketed former and thus gives the pipe an initial skin cooling, and final cooling is accomplished in the cooling tank itself. This method requires plugging of the pipe to maintain the internal pressure. The former box method is mostly used when extruding thin wall rigid pipe.

When the swaging die is used the extruded pipe is drawn down to the desired final size. It should be noted that the swaging die is a few thousandths larger than the desired finish pipe size to allow for contraction of the pipe during cooling.

CONCLUSION

In conclusion, it is significant to note again the marked interest and growing demand for rigid PVC. The background of varied installations that is being gained in this country to say nothing of the years of experience on the Continent indicates that this material is establishing a firm position in the thermoplastic field.

I extend my sincere thanks to the following SPE Professional Activity Committee members who have materially contributed to this paper.

Mr. Robert Bukey, Mgr. Sales Service Dept. Firestone Plastics, Pottstown, Pa.

Mr. Lee Samler, Tech. Dir. National Plastics Products Co., Odentown, Md.

Mr. Tom Winstead, President, Hedwin Corp., Baltimore, Md.

You Can't Win Dept.

Tensile smensile! The boss wants something he can color.

LOAD HIGH HOPPERS WITH IMS MATERIAL HOIST

The Economical Way

Most Efficient Pneumatic Hoist — Saves Labor, Time, Space — Boosts Production

EASY TO CLEAN

Eliminates dangerous scaffolds, saves floor space, saves spilled materials and lost cycles. Ideal for extruders and large injection machines.

Stock Model, Price Complete $674.50

For 220-volt, 3-phase operation

INJECTION MOLDERS SUPPLY CO.

PENTON BLDG. · CLEVELAND 13, OHIO

JOURNAL

Official Publication of The Society of Plastics Engineers, Inc. 513 Security Bank Building, Athens, Ohio.

POSTMASTER. Forwarding and Return Postage Guaranteed.

UNIVERSITY OF MICHIGAN
GENERAL LIBRARY
ANN ARBOR MICHIGAN

7033

Plastics Scrap
AND SURPLUS VIRGIN MATERIALS
• BOUGHT • SOLD
• CUSTOM REPROCESSED

• VINYL
METHYL METHACRYLATE
POLYSTYRENE • ACETATE
BUTYRATE • POLYETHYLENE
ETHYL CELLULOSE • NYLON

A. BAMBERGER
CORPORATION
703 BEDFORD AVENUE, BROOKLYN 6, N. Y.
PHONE MAin 5-7450 • CABLE CHEMPROD BROOKLYN
Branch Office: 8 East Long Street, Columbus, Ohio • MAin 4877

Real MOLD TEMPERATURE CONTROL, by THERMOLATOR*

can do amazing things in eliminating Sink Marks, Bubbles, Blisters, Crazing, Prominent Welds, Silver Streaks, Warpage, Strains, Poor Surface Finish, Dimensional Instability . . . and in speeding production.

We'll gladly share with you the experience of other molders who have found it profitable to install THERMOLATORS on their presses.

PORTABLE MODELS, AND FULLY AUTOMATIC MODELS WITH REMOTE PANEL-MOUNTED CONTROLS

*Reg. U.S. Pat. Office

Industrial MFG. CORP.
Specialists in Industrial Heat Transfer by Liquids
31 E. GEORGIA ST. • INDIANAPOLIS 4, IND.

MOLD DESIGN • PRODUCT DESIGN • CONSULTATION • DEVELOPMENTAL MOLDING

BARRIER—PRIBBLE & CO., INC.
CONSULTANTS IN PLASTICS

Phone—Fort Wayne, Ind
New Haven 5273

554 Eben St.
New Haven, Ind.

Dear Friends:

I promised you last month that we would have some secrets revealed here, but it looks like the first one is going to remain a secret for a little longer. You have kept us so busy that we haven't had time to decide just how to reveal the secret. "Jerry" Jehl (that's my man Friday) says a fellow just can't up and say, "Now, here is a secret!". Other people say "You have to have an air of mystery". Well, that may be true but it is certainly no mystery how we try to give you the very best possible engineering service. It just takes late hours (ask my family) and a lot of attention to minute detail. I did find time to get to Washington for the reinforced plastics meeting and was glad to see many of you there. If you learned as much as I did, we all learned a lot.

Yours for "Better Living with Plastics"
Wayne I. Pribble